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DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
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MINDANAO AND THE SULU ARCHIPELAGO: THEIR NATURAL RESOURCES AND OPPORTUNITIES FOR DEVELOPMENT

By

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MANILA
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FOREWORD

During his service as agricultural advisor in the Department of Mindanao and Sulu in 1917–1919, the author made an effort to gather especially data having a bearing upon the natural resources and the economic development of Mindanao from which as a basis a series of articles were written for *The Philippine Agricultural Review* in 1920–21. After eliminating the descriptions of fruit trees and the lists of the food plants, these have here been brought together in bulletin form, to which descriptions of Misamis and Surigao have been added for completion.

The need of more specific information relative to the subject under discussion is by no one more keenly realized than the author, but it is hoped that until more detailed knowledge shall have been accumulated relative to Mindanao the present publication will be found a useful forerunner.

The author is under obligations to former Governor F. W. Carpenter, Department of Mindanao and Sulu, for access to the provincial annual reports for 1914 to 1918, and to Colonel Ole Waloe, Philippine Constabulary, for the opportunity to consult the Constabulary provincial monographs, from which latter much of the geographical information has been obtained. Mr. Carl M. Moore, then Superintendent of Schools, Mindanao and Sulu, assisted with reports on Davao and the Cotabato Valley, by W. F. L. Asimont, which have also been drawn upon for information. The projected railroad routes on the map of Mindanao were traced with the assistance of former Major G. O. Fort, Philippine Constabulary, than whom no one is better informed relative to the topography of that Island. He also has corrected several geographical errors which crept in in the articles when first published. Except where stated otherwise the rainfall tables have been prepared from publications issued by the Weather Bureau, Manila. The agricultural statistics have been furnished by Mr. Antonio Peña, chief, division of statistics of this Bureau. Mr. H. E. Neibert, formerly supervising surveyor, Bureau of Lands, provided blueprints from which the provincial maps were traced. All the marine charts have been furnished by the Director, United

States Coast and Geodetic Survey, who also presented a map of Mindanao used in tracing that shown on Plate I. The photographs for Plates II, III, IV, V, VIII *b*, IX, X, XI, XXVII, XXXVI, and XXXVII have been obtained from the Bureau of Science. All others have been made from photographs taken by the author.

P. J. WESTER

MANILA, P. I., *February 7, 1922*

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MINDANAO AND THE SULU ARCHIPELAGO: THEIR NATURAL RESOURCES AND OPPORTUNITIES FOR DEVELOPMENT

GENERAL STATEMENT

Mindanao is still a comparatively unknown land. Less than half a score of men have traveled widely enough to know it well, and much of the information gained has never found its way into print. Meteorological data are scant for extensive areas. No complete systematic geologic and soil survey has been made. In a botanical sense the interior of the island is only partly explored. But it is evident even to the casual traveler that Mindanao is very rich in natural resources, and capable of production of the great tropical staples of commerce on a very large scale.

The second largest of the islands in the Philippine Archipelago, Mindanao was first discovered by the Spaniards. It is 36,906 square miles in extent and about equals in area the State of Indiana; it is some 11,600 square miles larger than Ceylon, nearly ten times the size of Porto Rico, and more than three times as large as Belgium. The population numbers somewhat less than 800,000 souls or about 22 to the square mile. Everything considered, it is the richest in natural resources, yet it is the least developed of all the larger islands, and much of the land still remains unexplored.

While Mindanao was the first island in the Philippines on which Magellan landed on his arrival 400 years ago, the Spaniards never gained full control there and were still warring with the Moros at the time of the outbreak of the Spanish-American war in 1898. Intermittent warfare continued between the American troops and the Moros some years after American occupation of the Philippines until civil government was inaugurated in 1914, and the present provincial divisions were established as parts of the Department of Mindanao and Sulu; Misamis and Surigao excepted, which were organized as provincial units by the Spaniards. In 1919, the Department of Mindanao and Sulu in turn was abolished and the provinces placed on the status of the older provinces in the Philippines.

Climatically, Mindanao is more favorably situated than all the larger islands in the Archipelago to the north. The northeastern corner excepted, Mindanao is below the so-called typhoon belt. As a whole, the rainfall is more equally distributed throughout the year than in Luzon and the Visayas.

Dividing the island into three zones the Rev. José Coronas, chief, meteorological division, Weather Bureau, in the *Climate and Weather of the Philippines, 1903 to 1918,* says that eastern Mindanao from about the head of Davao Gulf to Bagakay Point, south of Camigin Island, is of the second type with no dry periods and the maximum rainfall in the winter; and, excepting Bukidnon north of about the eighth parallel and Misamis east of Lanao, and the western part of the Zamboanga peninsula to about 122° 30′ east longitude which belong to the intermediate "A" type with no pronounced maximum rain period and a short dry season lasting from one to three months, the rest of Mindanao belongs to the intermediate "B" type with no pronounced maximum rain period and no dry season.

The topography of the country renders an unusually large proportion of the island available for agricultural purposes, and the soil is virgin and exceedingly fertile. Practically every tropical crop can be grown there.

Of the total area of approximately 9,850,000 hectares, it is conservatively estimated that three-fifths is good agricultural land. But let us assume that only 3,000,000 hectares are in cultivation to seven of the leading crops. The crops that, at a very conservative estimate, might be harvested from this area as shown in the following table are suggestive of the potential agricultural wealth of Mindanao:

Crop	Area, hectares	Yield, metric tons
Rice	400, 000	520, 000
Coconuts (copra)	600, 000	600, 000
Rubber	500, 000	150, 000
Coffee	400, 000	240, 000
Tea	200, 000	270, 000
Abacá	300, 000	180, 000
Sugar cane (sugar)	200, 000	1, 200, 000

The forests of Mindanao are very extensive and will furnish large quantities of excellent lumber for domestic consumption and export for a long period of years, aside from minor products, such as rattan and almaciga. There are approximately 90,000 hectares in mangrove from which large quantities of tanning extracts could be obtained. And by planting nipa palms to take the place of the mangrove an inexhaustible source of motor fuel would be provided. Nipa is already found in many places on the sea coast, and the largest nipa swamp in the Philippines, approximately 9,000 hectares in extent, is located in Lanao Province on Pañgil Bay. According to the investigations made by the Bureau of Science, systematically tapped for alcohol manufacture, this could be made to annually yield more than 17,500,000 liters of 90 per cent alcohol. In the face of the annually increased importation of motor driven farm machinery, trucks and automobiles with a correspondingly increased importation of gasoline and other petroleum derivatives at steadily advancing prices, the value of the nipa swamps as a future source of motor fuel assumes more than ordinary significance.

Should the coal beds of Malangas and the oil deposits in Pidatan prove sufficiently extensive they would prove another source of wealth of inestimable value in connection with the development of the Philippines.

The waters surrounding Mindanao abound in fish of many kinds and fisheries of large proportions could be developed.

Except in Davao, where it has been imported for several years, labor is still available for operating moderate sized plantations, but development of projects of any considerable magnitude presupposes the importation of practically all labor as a matter of course.

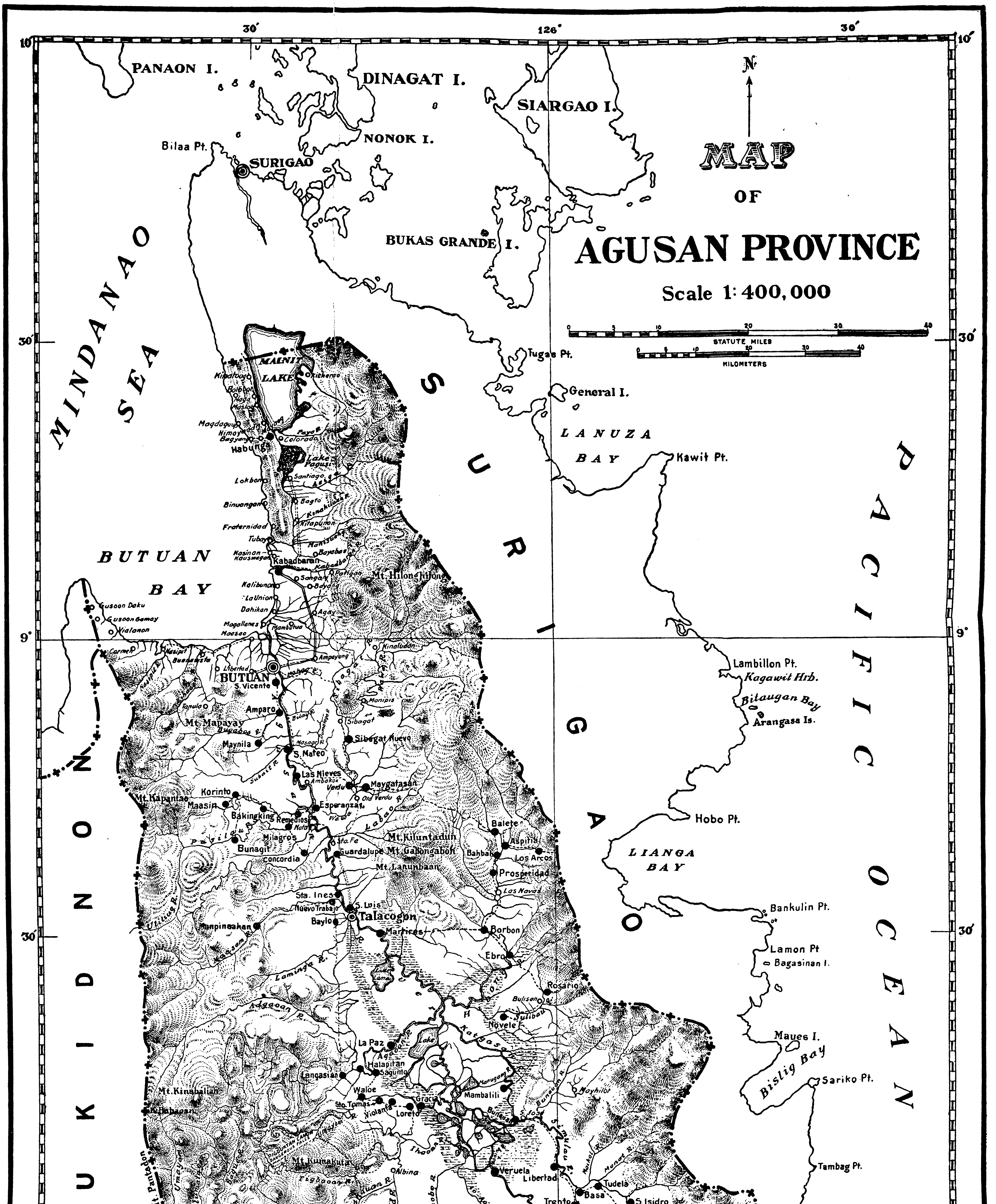
The many rivers with their numerous falls and rapids would be a valuable source of power for industrial and transportation purposes and for irrigation. The Agusan and especially the Cotabato River could also be developed into important waterways. In considering the internal transportation problem relative to the future economic development of Mindanao in its broadest sense, in relation to the topographical features of the island, including that of convenient outlets for the largest and the most fertile regions through natural harbors where port works could be most economically constructed, combined with well drained, attractive town sites, the routes traced on Plate I with the assistance of former Major G. O. Fort, Philippine Constabulary, than whom no one is better informed relative to the topography of Mindanao, are suggested as the most advantageous and along the lines of least resistance.

The natural advantages of Nasipit, Parang, and Malalag for terminals have already been discussed in the articles on Agusan, Cotabato, and Davao, and are too obvious to need further comment. More exposed, Kolambugan, next to Nasipit, has the greatest natural advantages for a railway terminal and deep water port on the north coast of Mindanao. Cagayan also has been proposed as a terminus but the limited area for anchorage, the poor town site, combined with the probable high cost of construction of a railway climbing from Cagayan to the Bukidnon plains, would be likely to militate against a road being located there, considering the more favorable approach to the interior through a richer agricultural country from Parang or Kolambugan.

For a road passing through the rich Cotabato Valley to Sarangani Bay, Makár or possibly Buayan would be the best terminal. On the line from Nasipit to Malalag one branch line to Lianga Bay and another to Mati on the Pacific coast may be found advantageous, and still another to Hijo at the head of Davao Gulf which is probably preferable as a town site to swampy Tagum. On the way to Malalag the road would pass through or a short distance west of Davao, but because of the low and swampy land, shallow water and the open, unprotected roadstead at Santa Ana, the landing place, it is not believed that the establishment here of a large deep water port is warranted in face of the superior advantages of Malalag with its land locked harbor, where the ships can approach closer to the shore, where the land is higher and well drained, and affords a good town site.

In short, the arguments in favor of the development of a port at Caldera Bay presented on another page are equally pertinent relative to the location of a large deep water port at Malalag instead of Davao. The anchorages at Digos, Mampissin, and south of the mouth of the Lasang River are also worthy of note.

It has been said that the Philippines is the richest undeveloped region on the earth today. A broad statement. That it stands in the front rank is unquestioned, however. As the second largest island in the Archipelago and well known to possess greater natural advantages than any of the others, therefore, the development of Mindanao presents a fascinating subject to the student of economics, and an unusual opportunity for constructive statesmanship. But before permanent public improvements of any magnitude are undertaken, it would appear prudent and desirable to make a thorough physiographic survey of the island and work out a comprehensive and detailed plan for the construction of highways, ports, and irrigation works, which should be located less with an eye to the negligible present than to serve the greater future.



DIV. OF FARM STATISTICS, BUR OF AGRICULTURE, MANILA.

Traced by C.N. Villanueva 10-23-20

AGUSAN PROVINCE

AGUSAN

GENERAL DESCRIPTION

Agusan Province (Plate II) is located between 8° and 9° 29′ north latitude and between 125° 12′ and 126° 20′ east longitude, and is bounded on the north by Butuan Bay and Surigao Province, on the east by Surigao, on the south by Davao Province and on the west by the Provinces of Bukidnon and Misamis on the Island of Mindanao. It has an area of 4,294 square miles, a population of 44,183 inhabitants, and comes within 696 square miles of being equal to the State of Connecticut in area.

Mountain chains, with here and there peaks rising to an elevation of from 1,000 to nearly 2,000 meters, form the east and west boundaries, from which there is a more or less rapid descent to the Agusan Valley, which occupies the larger part of the province. In the north eastern part of Agusan another smaller valley is formed by the Tubay River, which rises in Lake Mainit on the Surigao border.

According to the estimates and surveys made by the Bureau of Forestry in 1919, out of a total area of 1,112,146 hectares, only 57,935 hectares or 5.2 per cent are under cultivation. The swamps and lakes in the interior are estimated at 50,000 hectares, or 4.26 per cent of the total area, while the salt water swamp along the coast covers an area of 4,400 hectares. Most of the land, or 961,830 hectares, 86.5 per cent, is covered by commercial forests.

The Agusan River is the central feature of the province which it has given its name. With a total length of 386 kilometers (240 miles)—of which 12 kilometers are navigable for interisland steamers with a draft of 8 to 9 feet, except during the driest part of the year, and for smaller river craft to Patrocinio, located on the boundary between Agusan and Davao, for a distance of about 250 kilometers—the Agusan is one of the three largest rivers in the Philippine Archipelago. The river has its source in Davao near the Pacific coast west of Karaga, south of the head of the Davao Gulf and flows with many turns and windings in a northerly direction to empty into Butuan Bay. At the mouth the Agusan is over a mile wide (1.65 kilometers) and the effect of the tide is felt some 25 kilometers up the river. At San Vicente the river is still 200 meters wide and at its exit from the lake region it is 120 meters broad.

The "Lower Agusan" is rather sluggish, while the current farther south ordinarily is but moderately rapid and the ascent is easily made by launch (Plate V). In flood times the current is more rapid, the river overflows its banks and inundates the surrounding country, the current carrying with it numerous logs, trees and other débris that render navigation difficult and dangerous. Among the numerous tributaries of the Agusan the Wawa, Hibung, Simulao, Ohot, Umayam, Adgaoan, and the Ihawan Rivers are the largest and the most important. These rivers in turn receive the water of numerous smaller streams making the province a veritable network of water courses.

The Wawa rises north of Mount Hilonghilong and flows in a southerly direction until it enters the Agusan at Esperanza. Ordinarily the Wawa is navigable for barotos to Verdu only owing to the rapid current of the river.

The Hibung River, quite deep and of moderate current, and with numerous tributaries, flows with many windings in a southerly direction until it turns westward and enters the Agusan opposite the Adgaoan River. Except in periods of droughts the Hibung is navigable to Prosperidad for river craft having a draft of 4 to 5 feet.

The Simulao River, which rises on Mount Bagumbun near the Davao boundary flows first in an easterly direction, then bends to the north and northwest, and finally enters the Agusan a short distance south of the confluence of that river and the Hibung. The lower end of Simulao is navigable for small launches to Bunawan, up to which point it is also commonly known as the Katgasan River.

The Umayan River rises on the slopes of Mount Babaon on the Bukidnon Boundary. Through a mountain district it flows southward for a distance of about 35 kilometers, turns east and then northward and after passing the Pigduktan falls, winds its way to the Agusan River. The lower course of the Umayam is navigable for launches drawing 5 feet of water to Loreto, and from there to Waloe by barotos.

The Adgaoan rises near the source of the Umayan but flows in the opposite direction, then proceeds on its tortuous course in an easterly direction until it joins the Agusan opposite the mouth of the Hibung River. The Adgaoan is navigable for launches of 5 feet draft to La Paz and thence for barotos to Sagunto.

PLATE III

Scene in the lake region, upper Agusan River

PLATE IV

Virgin timber forest on the lower Agusan River

PLATE V

Typical river view on lower Agusan

The Tubay River, which forms the outlet for the water in beautiful Lake Mainit, about 14 miles long, 6 miles broad and about 50 square miles in extent and Lake Pagusi 25 meters above sea level, is navigable for launches for a distance of 20 kilometers from Lake Mainit to Lake Pagusi below which the rapids and the swift current render navigation impracticable except for barotos.

While in volume they do not compare with the Maria Christina falls in Lanao Province, the Pigduktan falls of the Umayam River, 150 meters high, greatly exceed them in height, being in fact, the highest falls of any considerable size in the Philippines. The Bugue falls on a tributary to Umayam are 101 meters high.

The more noteworthy mountains are the Urdaneta, south east of Lake Mainit near the Surigao boundary, 1,750 meters high; Mabaho of about the same height, a little farther south on the same mountain range; and Hilonghilong, still farther south, about 1,900 meters high. In the southwestern part of the province, Kinabalian, attaining a height of 1,350 meters, is the most prominent. Mayapay, southeast of Nasipit harbor is approximately 700 meters in height.

In the interest of the tourist, it is a pity that the Agusan is so far from Manila, for no other river in the Philippines so typifies the river of the tropics as pictured by the imagination quickened by reading the accounts of travelers and explorers, and it still retains its primeval beauty.

From the mouth of the river to Butuan the land is low, barely above tide water and the vegetation consists largely of mangrove and other salt water plants, a few coconuts appear from time to time, and here and there clumps of sago palms further inland beyond the influence of the salt water. At Butuan the land begins to rise slowly and is at considerable elevation above the river all the way to Talakogon. It is forested to the river banks, the trees overhanging the river frequently being draped to the mirroring water with climbing plants, mostly leguminous or convolvulaceous, in the greatest profusion, presenting a charming effect. A motor launch going up the river passes small clearings planted to corn, abacá and rice, and primitive houses or huts from time to time, into which timid women and children scurry at its approach while curiosity gets the better of the bolder male population, and they stand their ground to inspect the stranger. Round a turn in the river it may meet a native on a raft of bamboo loaded with supplies probably obtained by barter at some settlement farther inland. Clumsy crocodiles, agile iguanas and deliberately moving monkeys are a common sight. The slender, climbing rattans which gracefully rear their heads above the other, more opulent vegetation, and here and there a fish tail palm or "palma brava" tend to relieve the effect of the heavy vegetative luxuriance that at last becomes almost monotonous.

Talakogon, the gateway, so to speak, to the "lake region" is said to be a trifle more than 30 meters above sea level. If this statement is accurate the drainage of the vast swamps to the south should not present any very great engineering difficulties. The lake region is intersected by a bewildering number of streams, canals and rivers running in every direction, and woe to him who ignorant of the routes of travel guideless dares to enter the maze. Here and there the river bank is quite high though rapidly sloping downward into the impenetrable swamp beyond. Then again, the launch passes through narrow channels between seas of aquatic, floating grasses, in which now and then rise islands supporting a luxuriant vegetation among which attractive pandans with slender, tree-like trunks add to the picturesqueness of the landscape (Plate III). Absent nearer the coast, bamboos again make their appearance in the lake region, but it is a dwarf, bushy, slender species that is of but little value. Epiphytes of many kinds are common. Two species of *Vanilla* grow wild in Loreto and probably at other points.

The district usually called the "Lake Country" of Agusan extends from Talakogon in the north to Veruela in the south for a distance of some 55 kilometers. At its greatest width it is about 25 kilometers broad.

It is said that during a heavy flood in 1860 one of the branches of the Agusan was closed by the accumulation of débris floating down the river and that this was the beginning of the inundation of the lake country. In 1905 seismic disturbances caused a still further subsidence which is believed to be still in progress. Of the many "lakes," in this region, which are mostly small and very shallow, Lumao is the largest.

The land around Lake Mainit, the Tubay River and its tributaries forms another smaller and very attractive valley in the northeast of Agusan Province. The land here is well drained and the country is more exposed to the sea; the climate is cooler and less oppressive than in the Agusan Valley. The soil is fertile and well adapted to abacá, coconuts, coffee, rice, corn, and the various minor food crops.

CLIMATE

Among Americans the climate of Agusan does not enjoy a very good reputation. During the day it is hot, still and sultry, and the nights are cool and damp and heavy fogs settle over the valley and swamps.

This climate is due to the peculiar topographical features of the Agusan Valley, on all sides hemmed in by mountains shutting off the refreshing breeze from the sea except over a narrow strecth in the north. Then, too, the heavily forested valley retains more humidity than it would if the forest was cleared away—even were it not for the presence of the vast swamps and lakes. Earthquakes are frequent, though rarely destructive. Storms and typhoons seldom do much damage because of the protection afforded by the surrounding mountains. In the south of the province they are, as a matter of fact, of rare occurrence.

The mean monthly and annual rainfall of Butuan is as follows, according to the Weather Bureau:

	Millimeters
January	181.5
February	244.1
March	147.6
April	122.0
June	151.1
July	129.6
August	98.9
September	136.2
October	162.9
November	287.9
December	317.5
Total	2,105.8

The rainy days average 188 in number.

Thus it will be seen that the rainfall here is of fairly even distribution throughout the year with most of the rain falling from November to March. Destructive droughts are unknown. The precipitation is very much greater in the interior of the province and there, especially on the mountain slopes east of Agusan River, the annual rainfall probably does not fall much short of 4,000 millimeters. Floods are an annual occurrence in the upper Agusan Valley during the rainy period, but the swamps and lakes act as a natural reservoir and absorb the surplus water so that the lower or northern part of the valley as a rule is not affected by these inundations.

Floods usually are associated with destruction. But the regularly recurring annual floods of Agusan are more like those of the Nile in that as they retreat the muddy waters leave on the fields a thick deposit of the fertile soil they have washed down from the mountain slopes in the interior, annually renewing the fertility of the land.

POPULATION

As previously stated, according to the Census of 1918 the population of Agusan numbers 44,183 souls, of whom approximately 25,000 are "Non-Christians." The remainder are Christianized. A few Chinese traders live in the largest towns on the coast and rivers. There are very few Caucasians in the province.

The Christians are mostly Visayans, who live along the coasts and in the principal settlements along Agusan River and its tributaries. Of the Non-Christian inhabitants the Manobos predominate, inhabiting the country along the Agusan and its tributaries. They are of a strong and well developed physique and would undoubtedly make good plantation laborers. However, all told they do not number more than about 20,000. The Mandayas are but a few thousand in number and live in the upper Agusan Valley near the Davao boundary. They are of light complexion and well developed physically. While otherwise desirable because of their limited number these tribes cannot be considered as a possible factor in development work on a large scale for which labor must be imported.

The Mamanuas, a nomadic negroid race, believed to be the aborigines in this part of Mindanao, have been rapidly diminishing in numbers for many years and are probably doomed to early extinction. At present there are some 2,000 of them.

HISTORICAL REVIEW

One of the least developed of all the provinces in the Philippines the authentic history of Agusan is equally scant notwithstanding that Magellan made his first landing in the Philippines at the mouth of Agusan River in 1521 and took possession of the Archipelago for the crown of Spain. A concrete monument which is still standing in a small barrio called Magallanes, located to the left of Agusan River, was erected by the Spaniards in 1872 at the point of landing to commemorate the discovery. In 1709–10 the Spaniards first attempted to penetrate into the interior of Agusan, an ambition which appears to have been achieved without much resistance from the native inhabitants. Small settlements were made here and there along the rivers though the Spaniards never exercised practically any control over the natives.

Butuan has been the capital of Agusan for about 100 years. It was first located at the point of landing by Magellan, but because of its exposure to the floods of the Agusan the town was in 1868 removed to Banza barrio, about 5 kilometers above Magallanes. For the same reason it was again transferred in 1878 to its present site on the right side of Agusan River, about 6 kilometers inland. At present Butuan and Kabadbaran are the only two towns in Agusan where interisland steamers call regularly. While settlements were made and missions started by the Jesuits in the interior prior to that date, it does not appear that any organized attempt to civilize the native inhabitants was made until in 1873, when several villages or towns were first organized both on the coast and in the interior of the province. In 1885 there were 24 organized settlements. The occupation by Americans was effected without notable incident, and under the name of Butuan the province was administered by the Secretary of the Interior as one of the "Non-Christian provinces" until 1914 when the present organization took effect, and Agusan became a province in the Department of Mindanao and Sulu.

AGRICULTURE AND FOOD CROPS

Mountainous in the east and west, the soil has been carried from the higher elevation by the water in the innumerable rivers and streams and deposited in the central part of the province thus making extraordinarily fertile a broad valley of which but an infinitesimal area has as yet been brought under cultivation.

Agriculture in Agusan is in a primitive stage. Abacá and copra are the principal crops. The abacá is produced mostly along the Agusan, its tributaries and the Tubay River. The coconuts are found on the coast and up to Butuan on the river. Few coconut palms are seen in the interior of the province. A comparatively large area is devoted to corn, a more prominent crop in Agusan than rice, which is still an import item of this province. A small amount of tobacco is grown for home consumption.

The agricultural industries of Agusan rank as follows:

TABLE I.—*Agricultural statistics of Agusan, 1920*

Crop	Area in hectares	Yield	Value
			Pesos
Rice	2,499	[a]32,301	280,809
Sugar cane (sugar)	16	[b]11	1,290
Coconuts (copra)	3,425	[b]2,393	617,888
Abacá	5,355	[b]2,751	1,035,842
Corn	2,196	[a]18,208	133,071
Tobacco	21	[b]12	5,160
Total	13,512		2,073,060

[a] Hectoliters.

[b] Metric tons.

Other more common food crops are sugar cane, camotes, gabi, cassava, peanuts, squash, mungos, eggplants, tomatoes, and chili. The sago palm is also a source of food.

The sago palm, *Metroxylon sago* Rottb., flourishes over a considerable part of Agusan but the total area in sago swamps is apparently much smaller than in Cotabato, and it is doubtful whether the material is present in sufficient abundance to sustain a sago industry of any considerable magnitude. Here it may not be inopportune to recall that the sago palm has never been accorded the attention it deserves from civilized man. Yet, no starch producing plant will grow with so little care; it flourishes on land on which most other crops fail, once established the sago palm is established for many generations for unlike most other plams it suckers freely from the base and the creeping stems. The sago palm furnishes a wholesome, nourishing, and cheap food whose extraction and preparation requires no very expensive or intricate machinery. Easily as the plant is propagated, it would appear that the Government agencies with jurisdiction in Agusan might well consider the systematic extension of the Agusan sago swamps with a view of insuring an easily procurable local food in times of famine, also looking forward to the manufacture and export of sago sometime in the future which now is one of the import items in the Philippine Archipelago.

Among the fruits the durian, bauno, lanzon, banana, papaya, guava, pineapple, and jack are the most prominent. There are durian trees, *Durio zibethinus,* of enormous size and unquestionably very old all along the Agusan in the various settlements up to the Davao boundary, and large baunos, *Mangifera caesia,* of excellent quality are obtainable at Butuan when they are in season. South of Talakogon, at which point there are many large baunos, this trees has not been noted. On the right side of the river as one approaches Butuan there is a small forest of this excellent fruit and next to Jolo, Butuan is no doubt one of the best fields for selection work with a view of establishing standard superior varieties of the bauno. Here, too, it might be mentioned that near Momungan, Lanao, there is also said to exist a forest of baunos. Dillenias are common in the upper Agusan Valley, and the kamingi, *Litchi philippinensis,* is common around Lake Mainit. This latter species is a very handsome tree with a fruit of fairly good quality though much inferior to the litchi.

At present there are no large plantations in this province.

FOREST RESOURCES

According to the latest compilations made by the Philippine Bureau of Forestry, Agusan Province has 961,830 hectares of commercial forests, 86.5 per cent of the total area of the province, an area exceeded only by Cotabato, Davao, Zamboanga, and Palawan.

The forests include among others the following timber trees: apitong, *Dipterocarpus* sp.; mayapis, *Shorea squamata;* white lauan, *Pentacme contorta;* molave, *Vitex* sp.; amamanit, *Eucalyptus naudiniana;* toog, *Terminialia quadrialata;* tanguile, *Shorea* sp.; mancono, *Xanthostemon verdugonianus;* pagatpat, *Sonneratia pagatpat;* bagtikan, *Parashorea plicata;* dao, *Dracontomelum dao;* ipil, *Intsia bijuga;* narra, *Pterocarpus indicus;* camagon, *Diospyros discolor;* and guijo, *Shorea guiso.* Teak, *Tectonia grandis,* is also found but not in commercial quantities.

So far there are no saw mills in operation in Agusan, though in general the province is considered to present good opportunities for lumbering on a large scale (Plate IV). According to Mr. Rafael Medina, assistant director of Forestry, who made a survey of the forests of the province in 1915, the best site for a large central saw mill is on the Agusan River between San Vicente and Vitus. The large number of water courses could to great advantage be utilized in the transportation of logs from the forests to the mill.

Large quantities of rattans are obtainable from the forests. Beeswax and almaciga may also be gathered. The large mangrove swamps on the coast could sustain a cutch industry of considerable proportions.

RESOURCES OTHER THAN AGRICULTURE AND FORESTS

Agusan Province is not sufficiently explored to warrant definite statements relative to the mineral resources within its boundaries. Gold has been found in nearly all the rivers that originate east of Agusan but the extent of these deposists is unknown. Platinum finds have been made together with the gold. There is coal near San Vicente but no survey of the deposit nor quality tests have been made. Natural gas which burns readily has been discovered in Magallanes, and there are hot mineral springs in the Lake Mainit region and near Noveli in upper Agusan.

As elsewhere in the Philippines, there is an abundance of fish of all kinds in Butuan Bay and Lake Mainit is well stocked also. Fresh water fish in large quantities are caught in the lake country during the "dry" season.

COMMERCE AND COMMUNICATIONS

Abacá, copra, and bejuco constitute practically all the exports of Agusan.

Practically all interprovincial communication is by water on the Agusan River and its tributaries and on the Tubay. The province operates a small launch on the Agusan which makes regular trips between Butuan and Talakogon. The mileage of good roads is insignificant. The principal municipalities are connected by a local telephone system, and Butuan has cable communications with Manila and other points via Cebu.

Several inter-island steamers call at Butuan and Kabadbaran regularly and now and then at Tubay and Nasipit. One hundred and fifty-five steamers called at Butuan during 1918.

The value of the rivers and streams for navigation has already been indicated on page 13 in addition to which many smaller streams are navigable for barotos for longer or shorter distances depending upon the season and the flow of water.

PROSPECTIVE INDUSTRIES AND FUTURE DEVELOPMENT

At present one of the least known and least advanced provinces in the Philippines, when the broad valley of marvelously fertile soil, its abundant and evenly distributed rainfall, and its protected situation and vast forests are considered, it would seem that one is justified in the prediction that in Agusan capital and labor are all that are required to transform the wilderness into an enormously productive country. Harnessed, the rivers and streams would be capable of furnishing more power than ever will be required either for industrial or transportation purposes, and once they are dredged and straightened they would furnish a cheap mode of transportation for much of the produce. They would provide a never failing water supply for irrigation purposes were that needed, but that is unlikely, however, in a region where the rainfall is so remarkably well distributed and so abundant as in Agusan. Lastly, at Nasipit, Agusan possesses the finest harbor on the north coast of the Island of Mindanao, which some day will unquestionably become one of the principal terminals of the future railroad system of Mindanao and the outlet for the products of Agusan and northern Davao. The Agusan River affords good protection for shipping but because of the bar formed by the silt and accumulated débris at the mouth of the river it is approachable only at high tide. With sufficient ship-

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ping to justify the expense a passage could, of course, be kept open by dredging. (See Plate VI.)

At present practically the only means of communication and routes of travel are along the Agusan River and its tributaries, and the casual traveler who does not have the time or the inclination to penetrate inland from the rivers is apt to carry with him the impression that Agusan is divided between swamps and a network of sluggish rivers. True, Cotabato perharps excepted, Agusan has a larger area of swamp lands than any other province in the Philippines, and the climate is considered depressive. However, this condition applies to the low and swampy areas near the rivers and on the coast, and there is no reason why the more elevated areas removed from the swamps and rivers should not be desirable land for settlers. It is true, of course, that this land is less accessible than other, equally good farming land in other parts of the islands, and for that reason Agusan Valley will probably remain an unsettled region for many years unless a corporation with ample capital should obtain concessions for development on a very large scale. On the other hand, the valley around the Tubay River and Lake Mainit in the northeastern corner of the province and the well drained lands along the coast afford a large area of fertile land eminently adapted to colonization by settlers of small means who might wish to make their home in Agusan.

As may already have been noted the development of Agusan all lies in the future, and to the promotor and pioneer with sufficient capital and imagination the province with its unusual opportunities for development, presents a fascinating aspect. Here is an opportunity to shape the future history of a province as large as some states in the American Union and to predetermine its industries and the routes of its highways, within certain limits to predicate even its future inhabitants.

An enterprise conceived on sufficiently broad lines would naturally devote a large share of its energies to lumbering, especially in the beginning, but hand in hand could and should follow the development of big estates planted to coconut palms, Para rubber, abacá, coffee, cassava, roselle, and jute, for all of which crops the region is preëminently suited. Extensive sago palm plantations might be established. It would be necessary to straighten out the Agusan River and some of its tributaries to more rapidly drain off an excess of water during the rainy period and to shorten the distances for transportation.

The rafting of the logs on the rivers would require supplementary logging railroads. Then, the opening of the interior of the province and the need for overland rapid transportation and connections with Davao and Cotabato would demand the construction of a railway from Nasipit to the Davao Gulf. From Azpitia a branch line to Lianga Bay on the Pacific coast might be found desirable.

For an enterprise of this magnitude, Nasipit with its excellent, well protected harbor would be a convenient and attractive center of administration and an excellent site for mills, factories, and warehouses, as it would become also not only the principal port of Agusan but probably the largest export center on the north coast of Mindanao.

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BUKIDNON

GENERAL DESCRIPTION

Bukidnon (Plate VII) is an inland province in the Island of Mindanao, bounded on the north by Misamis, on the east by the provinces of Agusan and Davao, on the south by Cotabato, and on the west by Cotabato, Lanao, and Misamis, between 124° 19′ and 125° 20′ east longitude, and 7° 22′ to 9° 3′ north latitude. It has an area of 3,871 square miles and 45,000 inhabitants. In other words it is larger than the States of Rhode Island and Delaware combined.

The boundary of Bukidnon has been changed from time to time, and as now constituted in the east it follows a chain of mountains, as is also true of most of the Lanao-Bukidnon boundary. In the north the border line has been somewhat arbitrarily fixed along a line supposed to separate the Christian Filipinos from the Non-Christian people in the highlands of that part of Mindanao, in the south to separate the Bukidnons from the Cotabato Moros.

The present boundaries of Bukidnon, like all provincial boundary lines in Mindanao, have been drawn with a view of dividing the territory into provincial units that have common interests of communication, intercourse and population, that can be easily reached from the provincial capital and hence can be administered to the best advantage.

According to a table prepared by the Bureau of Forestry, in 1919, about 45 per cent of the area of Bukidnon, or 454,980 hectares, still remains commercial forest. There are 287,123 hectares, or 28.6 per cent of the land in prairie or cogon, *Imperata cylindrica;* only 2.2 per cent, or 21,660 hectares are in cultivation; 20.5 per cent, or 206,000 hectares, is still unexplored territory.

Topographically Bukidnon is a plateau land with vast, level, more or less rolling plains out of which rise several mountains with peaks here and there attaining an elevation of 1,500 meters or more, lying between a chain of forested mountains in the east and another in the west along the northern part of the Lanao border. While on the mountain slopes the tillable land frequently exceeds this elevation, the crest of the undulating plains is reached at Dalauangan at an elevation of 915 meters, whence there is a general downward slope to Misamis Province in the north and to Cotabato in the south. The plains are intersected by several large canyons of which the Kulaman canyon south of Maluko is the largest. Ravines with rivers or streams of abundant cold, clear water are numerous.

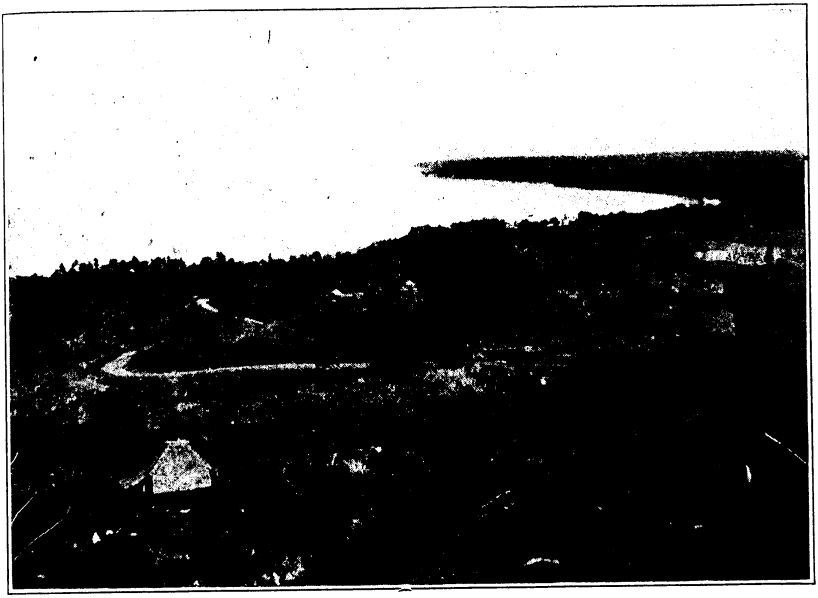
All the rivers in Bukidnon are too small or their descent is too rapid to permit navigation. The largest is the Pulangi or Cotabato River, rising in a small lake on Mt. Gimankil in the northeastern corner of the province, which together with its numerous tributaries, drains the eastern central and southern part of Bukidnon and enters Cotabato at Balatukan. (Plate VIII *b*.) The Cagayan River originates on Mt. Kitanglad and drains the northwestern part of Bukidnon emptying at Cagayan.

The Tagoloan River drains north-central Bukidnon, flowing into Makahalar Bay at Tagoloan. The numerous falls and rapids in the province have a sufficiently ample volume of water to permit the construction of many hydroelectric plants for industrial and transportation purposes.

Mt. Kitanglad, in about the center of Bukidnon, rising to an elevation of about 2,340 meters, and Mt. Kalatungan to the southwest of Kitanglad, perhaps 2,000 meters high, are the most prominent mountains. The rise of both these mountains is so gradual that the greater part of their slopes can be used for agricultural purposes. When transportation costs and the difficulties of approach are considered, were Cinchona culture in the Philippines on a large scale to be seriously contemplated, it seems not only possible but even probable that the higher slopes of Kitanglad and Kalatungan might be found preferable for this crop to the vastly more inaccessible country in the interior of the Mountain Province in northern Luzon.

Considering the topographical features of Bukidnon in relation to its accessibility and the routes of travel from the coast to the interior, Bukidnon may be divided into three districts.

1. The Claveria or northeast district including the territory north of Silo-o, Malitbog, and Santa Inés;
2. Central and south Bukidnon, including the country south of the mountain chain extending from Mt. Tago to Santa Inés west of Agusan River and east and south of the agglomerations of mountains about Kalatungan and Kitanglad;
3. The Talakag or western district, between the mountains just mentioned and the provinces of Lanao and Misamis.



(*a*) View on the road from the coast to Central Bukidnon. Makahalar Bay in the distance

(*b*) Falls of the Pulangi (Cotabato) River, near Maramag, Bukidnon

The Claveria district is reached by horse trails from Tagoloan in the south, and further north by trails which penetrate from the coast to the interior, where they are linked up by a trail running north and south throughout the district. The eastern part of this district is a heavily forested, unexplored mountain country. The western part along the Misamis border is a rolling plain overgrown with cogon, extending from north to south along the Misamis border. The average elevation of the agricultural country of this district is said to be about 600 meters.

Central Bukidnon is connected with Cagayan through Agusan, Tankulan, Maluko, Impasugong, Malaybalay, and Mailag to Valencia by a road passable for autos, which could at slight cost be extended a considerable distance farther south at least to Mauban. A first class road is under construction from Cagayan to Maluko, which has been completed from the coast almost to the boundary line between Misamis and Bukidnon. The remainder of the road is still unsurfaced, nevertheless is in very good condition except during heavy rains. The Kulaman canyon has not been bridged and must be crossed on horseback, after which the journey may be resumed by auto.

Traveling from the coast to the interior (Plate VIII *a*) there is a rather abrupt ascent to the first plain, which is about 230 meters above sea level. This plain, as one proceeds, rising slowly to an elevation of 375 meters, has a poor, sandy, gravelly and stony soil with numerous boulders scattered over the surface. The vegetation is a thin, short grass with here and there scrubby trees. Unfit for agricultural crops, this plain, however, could be used for grazing purposes though much inferior to the plains to the south in this respect also. At the southern end of this plain there is again a rise to a second table-land from 480 to 510 meters above sea level about Diklum, at Lindaban, rising to approximately 1,035 meters above the sea. To Dalirig and Maluko, at 410 meters altitude, there is a slow descent. Then, south of the Kulaman canyon spread the wide, open prairie plateaus to the south and southwest, extending westward beyond Sumilao, which has an elevation of 730 meters, rising slowly to 755 meters at Impolutao and to 915 meters at Dalauangan, from which the plains again fall away toward the south. Kalasungay registers an altitude of 690 and Malaybalay, the capital of Bukidnon, 620 meters. From Malaybalay there is a steady descent southward, with 240 meters at Bogkaon, 325 meters at Mailag, 300 meters at Valencia, and 240 meters at Dologon. South of Dologon there is again a slight rise to an average of about 300 meters, until the land again slowly slopes down and southward to merge with the grassy plains in the Cotabato Valley. Though there are exceptional areas here and there, generally speaking the land becomes more fertile as one travels southward. The vegetation on the plains consists of various grasses. While it is present, cogon, *Imperata cylindrica,* is not, as a rule, common on the plains north of Dalauangan. Not before one arrives south of Malaybalay does it begin to show more than the most ordinary vigor.

The fertile country about Linabo to Bogkaon gives way to poorer land in Mailag whence extends a billowy plain to Lurugan some 450 meters high above the sea. Then more pronounced hills covered with heavy cogon and secondary forest until one arrives in Giniyuran at 630 meters altitude. Finally, passing through the outskirts of the virgin forest one comes out on another cogonal valley at Dagumbaan. Northwest of this place lies a wide belt of virgin forest. In the southwest, as the Bukidnon country merges into Lanao and Cotabato the land is again mostly open. Again, the southern boundary of Bukidnon passes through a big virgin forest extending into northeastern Cotabato.

The Talakag district includes the northwestern part of Bukidnon between Lanao and Misamis, Mt. Kalatungan and Mt. Kitanglad, and the mountain chain extending from the latter mountain to Kiliog, and is reached from the cost by a road extending from Cagayan to Talakag and Tikalaan, almost due south. The valley is drained by the Cagayan River and its tributaries and is said to have an elevation of approximately 350 meters above sea level. The mountain chains in the west and northwest, along the Misamis and Lanao border, are covered by a commercial forest which descends even to the lower slopes and in the south extends to Mt. Kalatungan and Mt. Kitanglad. The remainder of the district is a vast, rolling grass-covered plain not greatly differing in characteristics from the central Bukidnon prairies.

On the whole the Talakag district is, perhaps, the most fertile part of Bukidnon.

The Bukidnon country everywhere is expressive of bigness and of latent undeveloped resources but nowhere is the scenery so impressively magnificent as in the open, wide-flung, verdant plains on the road from Malaybalay to Mailag, which must be seen in order to be appreciated. In many other provinces the soil is richer and the vegetation is more luxuriant, and they possess other advantages, such as convenient transportation; but nowhere else as here does the Philippines seize upon one's imagination and impress one's senses with their enormous latent wealth; their tremendous opportunities for economic development.

In scenic beauty the approach to Dansalan from Iligan is markedly superior to the ascent to Bukidnon, and Lake Lanao is, of course, an added attraction, but as a health resort for Mindanao and Visayas, Bukidnon is vastly preferable because of its drier climate. The higher elevations are also somewhat more accessible than in Lanao. Everything taken into consideration the upper slopes of Mt. Kitanglad and Mt. Kalatungan are, perhaps, more suitable for a health resort than any other locality in Mindanao.

Except for small patches of abacá, rice, corn, and various other food crops and some pasturage, the land is still unoccupied and open for settlement.

Game, in the form of deer, wild hogs, ducks, and pigeons is abundant.

CLIMATE AND SOIL

Due to the elevation the climate of Bukidnon is cool, bracing and exceedingly agreeable, especially in the higher altitudes, and as a rule a gentle breeze over the plains during the day adds still more to one's feeling of comfort.

Rainfall records are unfortunately entirely lacking in Bukidnon, but the precipitation is said to be well distributed throughout the year, the driest period occurring from January to May. The verdant plains which greet the eye of the traveler at all times of the year give credence to this statement.

Judging from the vegetation and such local information as it has been possible to obtain, the annual rainfall on the plains of Bukidnon probably approximates 1,800 millimeters annually, while on the higher mountain slopes it possibly exceeds 2,500 millimeters. Again, the volume of rainfall apparently increases as one goes southward, until at Maramag the annual precipitation is probably not less than 3,000 millimeters.

The soil varies from a poor, stony and gravelly soil near the Misamis border to a friable, rather thin loam or volcanic ash rather deficient in humus in central Bukidnon to quite rich lands in the south of the province. The greater part of the land is rich enough to produce good crops, but everything considered, the open plains of Bukidnon are inferior in fertility to the lands in Lanao and Cotabato.

POPULATION

The population is divided among Bukidnons, Manobos, Moros, Visayans, and Caucasians. Of these the Bukidnons are the most numerous, constituting probably one-half of the population. They are intelligent and industrious and make good laborers, and live in organized settlements on the plains. In numerical strength the Manobos rank second in importance, but as a large part of them still lead a semi-nomadic life, they can not be considered a factor in the agricultural development of the province. The number of Moros, who live mostly in the southern and western part of Bukidnon, is small. The Visayans are few in number, and there are probably not more than a dozen white residents in the province.

AGRICULTURAL INDUSTRIES

Rice, abacá, corn, and coffee constitute the principal crops of Bukidnon. The following table shows the present status of agriculture in the province:

The rice is exclusively upland and is grown on the plains. (Plate IX *a*.) On the average the soil in Bukidnon is thinner and poorer than in Lanao and Cotabato, and the yield is not equal to that in these provinces, but it is undeniable that very large quantities of rice, corn, and legumes could be grown on the vast highland plains of Bukidnon also, sufficient to sustain a large local population and yet leave a large surplus for export. The prospects for lowland rice are less favorable.

Very little corn and legumes are planted.

As in Cotabato, adlay, *Coix lacryma-jobi* L., is cultivated for its edible grain but, of course, on a very small scale, though it does well and is very productive. (Plate IX *b*.) It is by no means impossible that this may be found to be a profitable grain here. Wheat might be grown, though the yield would probably not be very heavy.

TABLE II.—*Agricultural statistics of Bukidnon, 1920*

Crop	Area in hectares	Yield	Value
			Pesos
Rice	1,020	[a] 8,871	54,864
Sugar cane (sugar)	93	[b] 30	9,263
Coconuts (copra)	96	[b] 25	7,600
Abacá	6,277	[b] 3,415	762,410
Corn	1,127	[a] 10,012	75,550
Tobacco	39	21	10,250
Total	8,652		919,937

[a] Hectoliters.

[b] Metric tons.

(*a*) View in the interior of Bukidnon

(*b*) Adlay, *Coix lacryma-jobi*, near Malaybalay, Bukidnon

Camotes and cassava are the most extensively planted rootcrops, though gabi is grown to some extent. Abacá is grown mostly in the canyons between the plains in the southeast towards Davao, and in the Talakag district. Coffee raising is mostly confined to the settlements on the mountain slopes and grown on a very small scale. (Plate X.) Few vegetables are planted but all temperate and most tropical ones thrive well under proper care. Excellent oranges and limes are found in some localities, such as Sumilao, but other fruits are scarce. Many species which are common in other parts of the Philippines still remain to be introduced in Bukidnon.

Bukidnon is preëminently a pastoral country, but all told the herds probably do not as yet number more than 12,000 head.

While there are several small herds of from 25 to sometimes exceeding 100 animals, there are only three herds of any considerable size, that of the Agusan Coconut Company, which now numbers about 4,000 animals, located at Tankulan, that of Mr. Dean C. Worcester, in Dalauangan; and that of the Bukidnon Cattle and Coffee Company in Santa Fé. This last corporation is also engaged in the breeding of pure-bred Indian cattle, horses, swine and poultry. Most of these herds are still made up of native cattle, but they are rapidly being converted into robust mestizo herds by the introduction of Indian Nellore bulls. (Plate XI *a*.)

At Mailag, half a day's ride beyond Malaybalay, horse raising in a small way has been quite successful. (Plate XI *b*.)

NATURAL RESOURCES AND INDUSTRIES OTHER THAN AGRICULTURAL

Lanao, excepted, Bukidnon has a smaller area of commercial forest than any of the provinces discussed in this volume of the REVIEW, and the forests are so distant from the coast that the expense of transportation of the lumber would be so excessive as compared with that produced nearer the coast in other parts of the Philippines that lumbering will probably never be undertaken in Bukidnon until the more accessible forests near the coast have been exhausted. Almaciga and bejuco are collected and exported in small quantities but the revenue from this source could be greatly increased.

Cinnamon, *Cinnamonum mindanaense,* locally known as *kami,* of very good quality grows wild in Bukidnon as in all other provinces in Mindanao, and bark might be collected in considerable quantities for export if the attention of the native inhabitants was called to its commercial value. During the Spanish occupation of the island this spice was exported from several points. As a matter of fact the cinnamon obtained from the *kami* is so good and the plant itself grows with such freedom that it is believed that a Philippine cinnamon industry could be established based on the culture of this species.

Buntong, the tall, stout bamboo so common at Lake Dapao in Lanao Province, is also found in Bukidnon, where it is used for construction purposes. Frequently attaining a diameter of 20 centimeters, the buntong is less durable and weaker than the ordinary bamboo, *Bambusa spinosa* Rxb.

TRANSPORTATION AND COMMUNICATIONS

Without sea coast and navigable rivers all transportation in Bukidnon is naturally on land. The status of the present road system has already been touched upon on a previous page. Here as in the other provinces a telephone system has been installed connecting all the more important municipalities and Cagayan, Misamis, which is the connecting link between Bukidnon and the outside world.

Cagayan is, of course, the seaport nearest to Bukidnon, but the protected anchorage is small, and the adjacent land is low and swampy (Plate XXVIII). Since a careful topographical survey would probably show that the interior of Bukidnon can be more easily approached at less cost by rail from Parang, Cotabato, than from Cagayan, the province is likely first thus to find an outlet to the sea at Parang with its superior natural advantages as a railroad terminus and harbor, or else at Kolambugan, Lanao, especially considering that there is already a good road from Cagayan to Bukidnon.

TRADE

Abacá and coffee are the only exports of importance, though small quantities of cacao, bejuco, and almaciga are also brought to the coast. Since the imports for 1918 amounted to about ₱80,000 the total exports probably did not greatly exceed ₱100,000 in value. Approximately one-third of the imports was rice. The other major imports were sugar, cloth, and salt.

PROSPECTIVE INDUSTRIES AND DEVELOPMENT

Because of the wide, well watered, verdant plains, Bukidnon is apparently predestined to become one of the principal stock raising provinces of the Philippines, and though the land is well adapted to a variety of crops one may expect this province to remain chiefly a pastoral country for many years ahead.

Arabian coffee in the third year. Sumilao, Bukidnon

(*a*) A herd of cattle. Tankulan, Bukidnon

(*b*) Native ponies. Bukidnon

The vegetation in Cotabato is more luxuriant, but in area Bukidnon is unrivalled as a prospective cattle region in Mindanao, and it is one of the four foremost provinces in the Archipelago in respect to area in pasturage. Corporations wishing to engage in stock raising would here find almost unlimited opportunities to engage in this industry in a big way and under exceptionally favorable conditions. The table lands have a cool climate that in the Philippines is unsurpassed in agricultural areas of similar extent, no mean advantage especially to the European. Good water is abundant everywhere. Again, the isolation of Bukidnon renders protection against contagious animal diseases a comparatively simple matter.

The Bukidnon coffee has attained an enviable reputation for quality but the production is limited in quantity. On a large scale Arabian coffee cannot, of course, be recommended for planting because of the *Hemileia,* but several of the blight resistant coffees from Java have shown up very favorably, and in time coffee may confidently be expected to rival stock raising in importance.

In the interior abacá is already quite an important product, comparatively speaking, and under the small culture system this crop may be extended very considerably though it is not recommended to the big planter. In this connection it might be said that to the homeseeker of limited means no province in Mindanao would appear more attractive than Bukidnon. The climate is healthy and agreeable, the water is good and plentiful, there is abundant pasture for cattle everywhere, the land is adapted to crops easily handled under a small culture system, such as rice, corn, and coffee, and it can be cleared without difficulty.

Tea has been introduced and there is apparently no reason why this crop should not be successfully grown on a large scale. As has already been stated on a previous page the prospects for cinchona culture in the Philippines are most favorable in Bukidnon. Camphor might be grown here also.

Ceara rubber was introduced many years ago and being easily propagated it has become dispersed to the most remote settlements. The trees have made a remarkable growth and it is by no means impossible that this rubber may become a crop of some importance in Bukidnon.

Except, perhaps, on the lower plains as one descends into Cotabato in southern Bukidnon, Para rubber and coconuts are not recommended as plantation crops for this province.

All plantation ventures presuppose the importation of labor from other regions.

Nowhere is the pineapple more at home than in Bukidnon. The fruit of the Cayenne variety, so extensively grown in Hawaii, and which has been grown at Diklum for several years is here unsurpassed in size and quality. With ample capital to push the project, a big, prosperous fruit canning industry might well be established here. In this connection it might be stated that the largest pineapple center in Hawaii is located in a region very similar to Bukidnon in the general topographical features, in elevation, climate and soil, though there is somewhat more rain in Bukidnon. As the Island of Mindanao is settled and convenient transportation routes are opened up, Bukidnon may be expected to supply the markets of Mindanao and the Visayas with citrus and other fruits requiring a cool climate for their best development.

Finally, the geographical location, climate and elevation combine to make Bukidnon—with special reference to Mt. Kitanglad and Mt. Kalatungan—the logical territory for a mountain resort for Mindanao and the Visayas.

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COTABATO

GENERAL DESCRIPTION

The Province of Cotabato (Plate XII) is located between 123° 57′ and 125° 30′ east longitude and between 5° 34′ and 7° 41′ north latitude. Occupying the major part of the huge peninsula that lies between the Celebes Sea on one side and is washed by the Davao Gulf and the Pacific Ocean on the other, it is bounded on the north by Lanao and Bukidnon, on the east by Davao, and on the south and west by the Celebes Sea, and contains an area of 9,620 square miles, being by far the largest province in the Philippines. In size it compares most nearly with Vermont in the United States, that state having an area of 9,565 square miles. Cotabato is three times as large as Porto Rico less 1,247 square miles, which has an area of only 3,604 square miles and it is about a third larger than the Hawaiian Islands, which contain 6,406 square miles.

Of this large territory, according to the latest survey of the Bureau of Forestry, Manila, 78.7 per cent, 1,960,530 hectares, is covered by commercial forest, 2.9 per cent, or 72,640 hectares is open grass lands; there is less than 2 per cent of the land in mangrove swamps and non-commercial forests, while 0.6 per cent, or less than 15,000 hectares are in cultivation. Some of these figures are subject to correction, since there are 16 per cent, or 402,880 hectares of land that still remains unexplored.

The more prominent mountains in Cotabato are Mount Matutum, 2,295 meters high, northwest of Sarangani Bay in the interior, and Arnold Hague, about 1,950 meters high. Piapayungan, 2,770 meters high, in the northwestern part of the province is the second highest mountain in the Philippines. Except the comparatively small area that drains into Sarangani Bay and the unexplored region on the southwest, the entire province is one vast basin of the Cotabato River and its numerous tributaries, of which the Alan, Libungan, Buluan, Maridagao, Kulaman, Kabakan, and Malitabug Rivers are the largest. The Cotabato River itself, under the name of Pulangi, originates in northern Bukidnon and is probably the longest river in the

Philippines. This river is navigable for small steamers to Fort Pikit, 74 miles from the sea, nearly all the year around, and at medium high water to Kabakan, a distance of more than 100 miles from the coast.

Owing to the fact that the several large tributaries of Cotabato originate and flow through widely separated localities in which the heaviest rainfall occurs at different times of the year, unlike the Agusan, the Cotabato River has no regular seasons of high and low water, the rise of the water is extremely irregular, and the inundations are unpredictable over a large area of land from Kabakan to the mouth of the river, with the consequent risk of destruction of the growing crops. Still, large as this area is, it is but a fraction of the total agricultural area of the province.

As one ascends the Cotabato River, at present the highway of the province, for several miles from the coast the banks, barely above tide water, support a vegetation of mangrove and other salt water plants. Further inland, as they rise to a higher level beyond the influence of salt water, the vegetation changes to tall grasses with here and there clumps of shrubby trees and sago palms. As the river leaves the fresh water swamps of the interior at Tumbao it branches into two arms and forms a delta country to the coast, penetrated by numerous cross channels.

Already before Cotabato, the capital of the province, is reached, a few tall coconut palms make their appearance on the low river banks and immobile, in the still air, they stand like sentinels on the river banks as if posted to challenge travelers all the way to Kabakan. Indeed, there is little else to relieve the monotony of the flat country. Here and there small Moro villages are passed clustering on the top of the river bank, the houses themselves scarcely visible through the thick growth of bananas and other fruit trees by which they are surrounded. Striking kapok and bangar trees meet the eye from time to time. The stately bauno is scarce, and so is the handsome, round topped, leafy inogug. Altogether, the lower part of the river is a flat, monotonous country of but little interest to the sight-seeing tourist. (Plate XIII.)

Mango trees are common but they are not the clean-limbed, dark green, handsome trees of Cavite and Batangas, but gnarled, and sparse-leaved. They look out of their natural element, due perhaps to the high water table and the frequent inundations.

(*a*) Typical scene on Cotabato River between the town of Cotabato and Fort Pikit

(*b*) Sago palms, *Methoxylon sagu*, on the banks of Cotabato River near the town of Cotabato

The stiff Buri palm, *Corypha elata* Rxb., is quite a common feature in the landscape. The spiny bamboo, *Bambusa spinosa* Rxb., also is well introduced. To the duck hunter certain sections in the swamps are a paradise. Crocodiles are common in the rivers and swamps.

Cotabato might be considered in the following divisions:

(1) North Cotabato or the Parang District, including the country north of the lands overflowed by Cotabato River, the swamps of the interior and the Kabakan River.

From the coast this country is a series of plains, largely denuded of forest, between hills and mountains, gradually rising as one goes further inland to an elevation of 500 meters on the plateau about Buldun. Further eastward the country is more mountainous and perhaps more forested but its general character is much the same. East and north of the Libungan swamps and the Malitabug River lies a wide stretch of open country gently rising towards the north and east. The northeastern corner of Cotabato is said to be largely virgin forest.

(2) The Cotabato delta and the swamp lands in the interior, including the Libungan and the Liguasan swamps.

Actual surveys have never been made but it is conservatively estimated that the big Liguasan swamp covers an area of some 300 square miles. Including this and the Libungan swamp the marsh and delta lands probably do not fall much short of 700 square miles. Buluan is a shallow lake about 40 square miles in extent. There are several smaller, some very attractive lakes in the province, but none of importance.

(3) Eastern and central Cotabato, including the plains south of Kabakan River and east and south of the swamps to the Sarangani watershed.

(4) The Sarangani District, including the watershed around Sarangani Bay, and

(5) The unexplored mountain region along the southwest coast. Several of the small rivers which find their way to the sea on this coast flow through small valleys of great fertility.

The country between Sarangani Bay and Lake Buluan is a wide, open plain, rising so gradually from the lowlands in the interior on one hand, and from Sarangani Bay on the other that the divide of the watershed is scarcely noticeable. Other large plains lie to the north and east of Sarangani Bay. While there is some very good land in the northern part, about Lake Buluan, much of the plain extending from Sarangani Bay to the north and northwest is said to be of but little value agriculturally except for a cattle range.

CLIMATE

At the higher elevations and on the coast the climate is cool and pleasant, but in the interior it is warm and sultry though the nights are almost invariably cool and agreeable. Rainfall observations are all too scant over the large territory under discussion, but so far as they are available they show a well distributed and ample rainfall with no prolonged dry periods.

According to the Weather Bureau, Manila, Cotabato, the capital, has a mean monthly and annual precipitations as follows:

TABLE III.—*Mean monthly and annual rainfall, Cotabato*

Month	Rainfall
	mm.
January	98.8
February	88.8
March	68.1
April	164.9
May	218.5
June	237.3
July	292.0
August	271.8
September	248.6
October	255.1
November	231.7
December	133.5
Total	2,309.1

The following table also has been published by the Weather Bureau.

TABLE IV.—*Rainfall at Tamontaka, Cotabato*

Month	1894	1895	1896
	mm.	*mm.*	*mm.*
January		21.7	101.0
February		30.5	70.0
March		128.0	
April		110.0	55.5
May	321.1	90.0	162.5
June	358.5	203.0	375.5
July	233.5		216.0
August	195.7		205.5
September	406.1		181.5
October	194.5		78.5
November	165.3		137.0
December	114.3		39.0
Total			

The following tables have been made from rainfall records forwarded by Mr. J. E. McCall, industrial supervisor, Bureau of Education, Cotabato, to the writer:

TABLE V.—*Rainfall in Cotabato*

Month	Kabakan			Kidapawan		
	1917	1918	1919	1917	1918	1919
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
January	252	196	69	86	294	48
February	97	289	81	73	275	137
March	178	302	124	166	277	75
April	110	226	80	312	220	138
May	204	844	194	269	446	383
June	676	421	265	318	551	296
July	235	58	184	220	208	295
August	60	147	55	265	127	195
September	115	99	340	273	142	307
October	103	175	235	413	227	326
November	113	107	97	283	104	216
December	112	114	118	240	68	255
Total	2,255	2,478	1,842	2,918	2,939	2,671

TABLE VI.—*Rainfall in Cotabato*

Month	Ladtingan			Buluan		
	1917	1918	1919	1917	1918	1919
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
January	205	332	64	71	192	13
February	114	208	44	48	258	20
March	140	221	52	43	121	28
April	184	216	66	17	157	36
May	206	152	259	151	176	196
June	254	319	179	211	248	342
July	235	101	160	309	164	138
August	276	191	63	273	121	88
September	191	117	158	107	247	130
October	307	92	147	151	55	243
November	199	66	59	281	26	172
December	193	83	50	115	133	115
Total	2,454	2,098	1,801	1,777	1,898	1,521

TABLE VII.—*Rainfall in Cotabato*

Month	Kudurangan			Buldun		
	1917	1918	1919	1917	1918	1919
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
January	150	241	47	186	417	136
February	140	69	66	278	301	12
March	91	106	100	203	255	177
April	127	193	79	387	223	259
May	222	192	273	363	283	516
June	296	258	148	316	548	358
July	255	138	146	294	354	380
August	224	118	32	226	240	416
September	162	92	184	237	166	768
October	328	133	187	534	499	713
November	116	102	141	387	257	457
December	132	100	110	251	334	272
Total	2,243	1,742	1,463	3,622	3,877	4,464

POPULATION

The population of Cotabato numbers 154,270, divided among Moros, Manobos, Bilans, Tirurays, Tagabilis, Dulangans, and Christian Filipinos, and a few scattered Americans, Chinese and Japanese, but by far the greater number of the inhabitants in Cotabato are Moros, belonging to two tribes, the Maguindanaos and the Iranuns. These people are widely scattered through the Cotabato Valley, and are the most advanced in civilization among the native inhabitants. Next in importance are the Manobos, who have settlements here and there in the more remote districts. The Bilans and Tirurays comprise several thousand people also living in the remote parts of Cotabato. The Tagabilis and Dulangans are very few. The Christian Filipinos live around Parang Bay and about Cotabato. Then there are quite a number who have been settled in agricultural colonies from Fort Pikit to Silik and at Glan within the past few years.

At present labor is plentiful at the few plantations that have been started, but corporations initiating development work of any magnitude would almost immediately be confronted with the problem of importing labor.

HISTORICAL REVIEW

The Spaniards first attempted to take possession of Cotabato in 1596 but the conquest was not permanent. A second expedition was sent in 1637, followed by several others from time to time for nearly 200 years, during which there was much blood shed by both belligerents. The more permanent occupation of Cotabato by the Spaniards dates from 1851, when a fort was begun and a naval base established at Polloc. From then on until the American occupation of Cotabato in 1899, there was intermittent fighting between the Moros and the Spaniards who ascended the river and erected one fort after another as far as Fort Pikit, where a very strong fort, still in good condition, was constructed on the hill in 1885. The military régime continued in force until in 1914 when civil government was established in Cotabato, organized as a province in the Department of Mindanao and Sulu.

AGRICULTURAL INDUSTRIES

In an undeveloped country like Cotabato agriculture also necessarily remains in an undeveloped state. Americans who have lived in the interior say that much upland rice is grown by merely cutting down the native, wild grasses at the approach of the rainy season. Then, when the floods come and the river inundates the land the cut vegetation decays, and when the waters subside the seed rice is sown. Harvesting is next in order. So rich is the soil and so favorable is the climate that the Moros get good rice crops by this primitive method of culture.

The agricultural crops of Cotabato were in 1920 as follows:

TABLE VIII.—*Agricultural statistics, Cotabato, 1920*

Crop	Area in hectares	Yield	Value
			Pesos
Rice	1,864	[a]22,168	150,371
Sugar cane (sugar)	11	[b]12	1,796
Coconuts (copra)	562	[b]166	41,745
Abacá	109	[b]29	11,600
Corn	537	[a]4,062	24,138
Total	3,083		229,650

[a] Hectoliters. [b] Metric tons.

From these figures it is readily seen that Cotabato is at the very beginning of her agricultural development.

Rice is, of course, by far the most important food crop grown in Cotabato, but other plants are also cultivated to supplement rice. Several varieties of corn are cultivated, among which are some dwarf varieties said to mature in 70 to 75 days after sowing the seed. At least three very distinct strains of edible adlay, *Coix lacryma-jobi*, have been recognized in a lot of this grain from Cotabato.

Many camote varieties are grown but generally are neither of good quality nor very productive. The Nito is a very early variety, said to mature in two months from the date of planting, and to be of good quality, and the Malukamba is reported to bear very large roots.

Several gabi varieties are also grown.

The vegetables grown include marutong, lyon beans, sincamas, patani, mungo, anipay, cowpea, sitao, peanuts, camote, cassava, squash, gabi, ubi, onions, tomato, pepper, chili, ginger, batao, eggplant, patola, apalia, and mustard. Several of these species are very recent introductions and they are as yet but sparsely grown.

The seeds of the lotus, *Nelumbium speciosum* Willd., is a food of considerable importance in Cotabato, and are common in the markets.

The banana is the most important of the fruits grown in Cotabato and a very large number of varieties are cultivated.

The mango, *Mangifera indica* L., is second in importance and the following varieties are recognized by the Moros and said to be true mangos: Dudul, Titi, Solo, Libas and Tay. The writer, who visited Cotabato during the mango season in May, 1919, when there was an abundance of mangos in the market, was unable to secure specimens of any but the Dudul and Titi.

Among the citrus fruits, though ordinarily poor, oranges and mandarins are occasionally produced of very good quality. Limes and dalayaps, *Citrus aurantifolia* var. *aromatica* West., of excellent quality, have been obtained. The most interesting citrus fruit noted is the "mangapug," which is apparently an unusually large form of *Citrus webberi* West. The principal ripening season occurs in December, but ripe fruits are found on the trees during the greater part of the year.

Occasional trees of the Inogug, an unidentified species of *Eugenia,* are found here and there along the river. This is so far as can be learned, not found elsewhere in the Islands.

The trees are very prolific, the fruit ripening from September to January when it is common in the markets, but occasional ripe fruits are said to be found on the tree throughout the year. The wood is fine grained and hard and makes good, durable timber. Aside from its value as a fruit, the Inogug is worthy of planting as an ornamental shade tree along roads and streets, and the tree well deserves wide dissemination in other parts of the tropics.

The total absence of *Nepheliums* and *Euphorias* along the Cotabato River is particularly striking in comparison with the numerous species belonging to these genera found in Bukidnon and Lanao. Durians, marangs and baunos are quite rare. Numerous large kayam trees grow in Pangi.

It is rather interesting to note that the native name of the Custardapple is here as in Sulu, "Salikaya," indicating that this fruit has been introduced from the Dutch East Indies.

Quite a number of mushrooms are collected and used for food by the natives. One of these is reported to be remarkably large, over 20 centimeters across.

PLANTATIONS

Several smaller plantation ventures have been started but the only large plantation in operation at present is the Rio Grande Rubber Company at Kalakan, which is 1,024 hectares in extent, with about 200 hectares planted to coconuts and Para rubber. The growth of the trees is good.

RESOURCES AND PRODUCTS OTHER THAN AGRICULTURAL

There are vague reports of the discovery of coal and gold in the northeastern part of Cotabato, but these rumors have never been verified. Oil of good quality has been discovered at Kerusoy in the neighborhood of Kerupe. How extensive these deposits are is not known but if oil should be found in any considerable abundance, the development of oil wells will become of the greatest importance not only for Cotabato and Mindanao but for the entire Philippine Archipelago.

In her enormous forests Cotabato has a source of great wealth immediately available for development on a very large scale. Not speaking of the large forests in the interior, the large, almost entirely unexplored mountain range on the southwest coast from Mount Kabalatan to Sarangani Bay, a distance of some 200 kilometers, forms a solid, broad belt of commercial forests containing both hard and soft wood. Among other trees the following species of timber trees are found in the Cotabato forests: Bagtican, *Parashorea plicata* Brand; white lauan, *Pentacme contorta* M. and R.; guijo, *Shorea guiso* Bl.; lumbayao, *Tarrietia javanica* Bl.; calantas, *Toona calantas* M. and R.; camagon, *Diospyros discolor* Willd.; ipil, *Intsia bijuga* O. Ktze; narra, *Pterocarpus indicus* Willd.; acle, *Albizzia acle* Merr.; tindalo, *Pahudia rhomboida* Prain, and *Intsia acuminata* Merr.; kalamansanai, *Neonauclea* sp.; ebony, *Maba buxifolia* Pers.; kamuning, *Murraya exotica* L. and palomaria, *Calophyllum inophyllum* L.

At present three sawmills are in operation in the province, one large mill in Lebak and two smaller ones in the town of Cotabato.

Some almaciga, gutta-percha, beeswax, lumbang nuts and bejuco are gathered in the forests and marketed, but the quantities obtained could be multiplied again and again, and tanbark in large quantities could be obtained for export from the mangrove swamps on the coast.

The hills south of Cotabato from Tamontaka to Awang contain a sticky, plastic clay which on investigation may be found of value for the manufacture of pottery, tiles and bricks.

The waters on the coast abound in fish of excellent quality.

COMMUNICATIONS AND TRANSPORTATION

The almost total lack of good roads is not the hardship one might suppose since the Cotabato River and its many tributaries are navigable for launches far into the interior and still farther inland are negotiable by barotos. For this reason most settlements are located on the rivers. Overland transportation is handled by means of pack animals.

Cotabato is connected with the outside world through the wireless stations in Lebak, and in Malabang, Lanao, and has a local telephone system connecting the principal towns in the province.. The steamers *Fernandez Hermanos, Neil McLeod* and *Mindanao* from Manila, call at Lebak and Cotabato at irregular intervals, and the steamship *Tablas* makes monthly calls at both points. The river steamer *Hall* makes regular trips on the Cotabato River as far as Fort Pikit and Kabakan and makes occasional trips to Parang and Lebak. The *Research* makes irregular trips from Zamboanga to Cotabato.

TRADE

The following table shows the exports from Cotabato from 1914 to 1918. From this it may be seen that lumber and rice are the only products of importance.

TABLE IX.—*Exports from Cotabato*

	1914	1915	1916	1917	1918
Lumber	₱213,747	₱2,700	₱153,788	₱241,628	₱240,047
Rice	185,975	54,362	110,099	134,387	105,624
Copra	7,183	4,556	8,173	41,420	29,436
Carabaos	----------	----------	----------	----------	13,220
Mats	----------	1,104	----------	820	12,565
Abacá	3,268	776	1,280	18,162	7,196
Peanuts	554	1,487	3,659	4,291	6,160
Palay (rough rice)	48,691	11,660	5,521	6,585	4,412
Fowls	----------	----------	----------	12	4,328
Hides	324	742	----------	240	2,244
Rice bran	2,944	747	446	1,677	1,777
Lumbang nuts	1,438	1,455	1,482	1,628	1,064
Miscellaneous	----------	----------	----------	----------	----------
Total	514,785	99,425	296,247	463,448	448,800

Small quantities of coffee, cacao, beeswax, gutta-percha, rubber, and rattans are also exported; in 1918 less than ₱1,000 for any one item. The largest in area of all the provinces in the Philippine Archipelago, Cotabato probably ranks lowest as a producer and exporter next to Bukidnon.

PROSPECTIVE INDUSTRIES AND FUTURE DEVELOPMENT

The different provinces in Mindanao each possess individual features that appeal to the prospective investor depending upon the industry in which he seeks to engage. But no other province equals Cotabato in potential wealth or in diversity of possible agricultural and other industries. Naturally this is to a large extent due to the size of the province, but is also in part due to its geographical and geological features and the vegetation.

With a larger area in commercial forests than any other province in the Philippines, as yet practically untouched, these will for a long period of years continue to yield great quantities of excellent timber. The mills alone are lacking. The more accessible forest is, of course, that on the coastal range from the mouth of the Cotabato to Sarangani Bay, but in the interior the Cotabato, Libungan, Maridigao, Malitabug, and Kulaman Rivers all penetrate virgin, commercial forests and they have a sufficiently large volume of water to permit the rafting of logs incident to lumbering.

The mangrove swamps on the coast would furnish tanbark in large quantities. Rattans, almaciga and other forest products could be obtained from the interior in far greater amounts than at presnt.

The materialization of the hopes relative to the oil finds would be of the greatest significance in the development of the northwestern part of the province, and would give great impetus to the development of Parang into a great shipping point.

On the big, open, grassy plains, between Sarangani Bay in the south to Lake Buluan, and on the rich, hilly pastures in the north from Parang over Buldun, to Banisilan and Bukidnon there is room for large cattle ranches.

At the lower elevations the soil and climate are favorable for the production of abacá, coconuts, coffee, and rubber over very large areas. Wide stretches of country continue suitable for coffee as one ascends to the higher plains north of Cotabato River, and here tea would also undoubtedly succeed well in many districts. With tractor cultivation upland or unirrigated rice could unquestionably be produced in great quantities and sugar haciendas could be opened up that would dwarf all previous similar undertakings in the Philippines into insignificance.

Then, there is the delta country, the land subject to the overflow of the Cotabato River and its tributaries and the adjacent swamps, the soil of which is inexhaustively fertile.

Due to the ever present menace of inundation very little land can sefely be farmed at present along the lower reaches of the Cotabato and Libungan. A region of exceptional potential wealth, it is at present a barren waste serving as a breeding ground for malarial fevers, it is a menace to health, and it bars the ready access to the more elevated, fertile country beyond. But it presents equally exceptionally vast opportunities for achievement and exploitation. The project might be financed by the National Government, but a concession granted to a large corporation would probably be preferable, as that would insure more rapid development. In any event the taming of this country with all that implies, fundamentally simple, would be one of the greatest engineering feast ever undertaken in these Islands. It would require the patient perseverance of a capable staff of administrators and engineers for many years. It is a project sufficiently vast to tax executive ability of a high order, and to fascinate the man of ambition, with a desire to achieve, aside from the mere monetary returns.

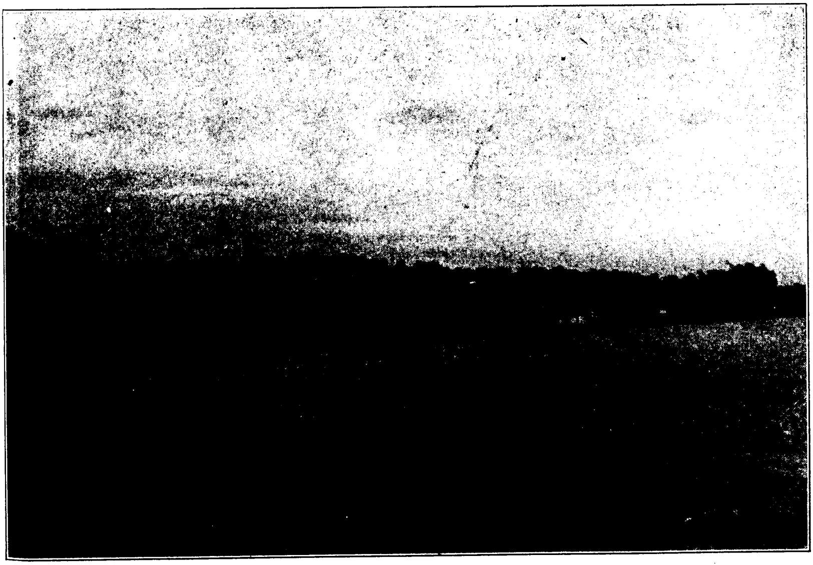
The project is a big one, but the problem is simple enough and would consist of the straightening of the rivers to induce a swifter flow of water, in the lower areas supplemented by the construction of dykes to prevent inundation during flood time. The drainage would also necessitate the dredging of a system of canals in the more depressed localities; but these would serve a triple purpose, as they would provide also a means of transportation and a source of water for irrigation in times of need. Thus, once the drainage and canal system was in working order, by the employment of tractors, on this great, level plain any of the important annual staple crops of the tropics such as rice, corn, sugar cane, tobacco, and jute, not to speak of indigo, cassava and peanuts, sesame and other crops, could be grown on an, for the Philippines, unprecedented scale.

Besides these greater products sago seems trifling, yet it is well to remember that the sago swamps of Cotabato exceed in area any others in the Philippines, those of Agusan not excepted, and they might well be systematically exploited and even extended.

No country can develop and prosper without a transportation system adequate to handle its traffic and afford good outlets for its trade.

In the development of the transportation system the several large rivers, and the canals in the present swamp region and delta, will unquestionably play a considerable rôle, but railways will be the greater arteries of trade. Railways are more or less urgently needed elsewhere incident to the development of Mindanao, but nowhere is the need so great, would the road meet less difficulties in construction, and would increased traffic follow quicker than on a railroad extending from Parang along the foothills of the mountains north of the Cotabato delta and the big swamps, over Kabakan and Kidapawan, terminating on Malalag Bay, on the Davao Gulf, with a branch line curving southward east of Lake Buluan to Makár or Buayan on Sarangani Bay. Excepting in the country south of Lake Buluan such a road would penetrate during its entire length an agricultural

(*a*) Entrance to Parang Bay. Bongo Island in the distance



(*b*) The village of Parang, 1919

Oversized
Foldout

land of unsurpassed fertility, which at present is practically uninhabited, and for all practical purposes is now inaccessible from the coast.

There are several good harbors on the Mindanao coast, but no other possesses so many advantages for the location of a great seaport and railroad terminus as Parang Bay. (Plate XIV.) The points in its favor may be summarized as follows:

(1) The bay is large enough to shelter a large fleet of vessels.

(2) There is deep water and excellent anchorage close to the shore, and piers could be constructed at low expenditure.

(3) The topographical features of the land around the bay for the planning of a large and attractive city are unusually good, the land has perfect drainage and a good slope from inland to the sea.

(4) An excellent and abundant supply of water is procurable within a short distance.

(5) Parang is within 45 kilometers of the oil discoveries in Pidatan.

(6) Parang is by far the nearest good harbor of any prospective importance to the coal field of Malangas—150 kilometers sailing distance.

(7) The approach to Parang of a railroad from the interior of Mindanao does not present any topographical difficulties and it is within easy reach of a very large and fertile country adapted to rice, corn, coconuts, rubber and coffee, and stock raising.

Also, one may confidently look forward to the day when Parang will be the center of trade and shipping not only of Cotabato Province alone but quite possibly of the entire Island of Mindanao.

DAVAO

GENERAL DESCRIPTION

The Province of Davao (Plate XVI) is located between 125° 9′ and 126° 36′ east longitude, and between 5° 20′ and 8° north latitude, in the southeast corner of the Island of Mindanao. It is bounded on the north by Agusan Province, on the east by the Pacific Ocean, on the south by the Celebes Sea and on the west by Cotabato and Bukidnon, and has a coast line of more than 600 kilometers. With an area of 7,486 square miles Davao nearly approximates in size the State of New Jersey, which has an area of 7,815 square miles, and it has a population of about 101,000 inhabitants according to the Census of 1918.

According to the most recent surveys and estimates of the Bureau of Forestry, Manila, 90.2 per cent, or 1,749,420 hectares of the area of Davao is still commercial forest, a greater area of woodland than that in any other province in the Philippines, Cotabato excepted. The land in cultivation includes but 30,730 hectares or 1.6 per cent of the total area. The open land and cogonales is probably not less than 50,000 hectares. These figures may require some readjustment, since there is an unexplored area of 6.1 per cent, or 117,564 hectares. There are quite extensive mangrove swamps at the head of the gulf.

In addition to the mainland Davao includes four fairly large Islands, Samal and Talikud, near the head of the Davao Gulf, Bulat and Sarangani off the southernmost point of the Island of Mindano, and several smaller ones scattered along the coast here and there.

Geographically Davao Gulf is the central feature of Davao Province and practically all plantations in the province extend inland from its shores. Few people realize that here in the southeast of the Philippine Archipelago there is a bay more than three times as large as the Bay of Manila.

The province itself is constituted of the eastern slope of the mountain chain that, roughly speaking, extends from north t south, west of Davao Gulf, the Agusan Valley south of the eight parallel, and the large peninsula to the southeast, terminati at Cape San Agustin.

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The topography of Davao is varied. There are large level or undulating plains, there are gently rising mountain slopes and rugged, precipitous mountains. The country is everywhere well watered by numerous streams and rivers, which, thanks to an evenly distributed rainfall, rarely or never run dry.

In a general way, the great bodies of agricultural land in Davao might be considered in two large regions. (1) The country in northern Davao drained by the Agusan River and its tributaries. This spacious, fertile country belongs topographically to the Agusan Valley and it is one of the finest bodies of virgin agricultural land in Mindanao. The present great drawback to this district is the absence of transportation facilities; and as yet the entire tract is lying idle, barring a few isolated patches of semicultivated land occupied by the native inhabitants. (2) The watershed of the Saug, Libuganon, Tagum and Hijo Rivers at the head of Davao Gulf and the country to the west and south thereof to Mount Apo and Malalag Bay west of the gulf, and east of the gulf to Mapanga Bay.

There are other valleys of greater or less dimensions of equally fertile land in the remainder of Davao, for instance, the country around Lais and Malita, at Kuabo, and north of Mati, but these areas are not comparable in size with those of the two large regions first mentioned. In the other coast districts, even where the mountains approach the coast, when the streams come within sight of the sea, as a rule the surrounding country spreads out in alluvial valleys of great fertility, sometimes small, not more than a few hundred hectares, to larger plains, sometimes exceeding a thousand hectares in area. Several of the Davao plantations are situated in such valleys. Though most of the better agricultural land in Davao is below this elevation, the Guianga plain to the northwest of the town of Davao ascends from 300 to over 600 meters altitude.

The southern part of Davao west of the gulf, from Sarangani Channel to Malalag Bay, is mountainous and forested from the Cotabato border to the coast. It is a rugged country, rich in timber but relatively unimportant from an agricultural point of view. Still, notable plantations are located here, such as those of the Culaman Plantation Company at Malita, one of the largest and most successful estates in Davao, and the Lais Development Company in Lais; and it is about Malita and Lais that the cultivation of rubber (Para and Castilloa) and Robusta coffee is concentrated in Davao.

From Malalag Bay and northward the country assumes a different aspect. The mountain ranges recede from the seashore and give room for broad, undulating plains, gradually rising as one travels westward, partly in virgin forest, in part cleared and overgrown with cogon, a tall, perennial grass. This is, in fact, a section of one of the large agricultural regions of Davao.

The narrow peninsula east of the gulf, from Kuabo southward, is a rough, mountainous land covered with virgin forests. The agricultural areas are small and located on the west coast of the peninsula.

The land from Mati to Manay for some distance inland is the principal cattle district in Davao.

In the river valleys the soil is, as a rule, a friable, rich alluvium, free from boulders and stones and frequently of great depth. Lands with good agricultural soil 3 to 4 meters deep are by no means uncommon. Now and then a sandy loam is encountered. Heavy clay soils are the exception. On the higher slopes of the mountain range facing Cotabato much of the soil is of volcanic origin and is exceedingly fertile.

The long coast line is indented by several large bays, such as Mapanga, Kuabo, Puhada, Mayo, Karaga, and Kateel.

Good anchorage and harbors for motor boats are located at the following points: Astorga, a few kilometers north of Santa Cruz; Butulan, north of the Sarangani Channel; Kalian, just north of Kalian Point; Kuabo, on the bay of the same name; Mapanga, on the bay of the same name; Patulangan, on the east coast of Davao Gulf just north of Santa Cruz; Tagabuli, a few kilometers south of Santa Cruz, at the mouth of the river of the same name; and Tubalan, on the west coast of Davao Gulf north of Malita.

Patoko and Tumanao, on the west coast of Sarangani Island afford good anchorage for steamers and motorboats. Mati, at the head of Puhada Bay has a good harbor for ocean-going steamers. This is also true of Monserrat, located some distance south of Kuabo Bay on the west coast of Davao Gulf.

The best harbor in the province is Malalag Bay, inside Kolapsin Point on the eastern shore of Davao Gulf.

Davao has a large number of streams and rivers of which the following are the largest and the most important:

The Agusan River, which originates west of Karaga and flows first westward and then in a northerly direction until it enters Agusan at Patrocinio and empties into Butuan Bay, on the north coast of Mindanao (See Agusan, page 13). The Agusan is navigable for motor boats to Veruela in Agusan Province and thence by baroto to Compostela, Davao.

The Kateel, emptying at Kateel, has a considerable volume of water but the current is too rapid to permit navigation.

The Davao River, emptying at Davao, the provincial capital, is navigable for small motor boats for about 10 miles inland.

The Lasang River is navigable for barotos for about 4 miles.

The Libuganon rises in the mountains in the northwestern corner of Davao and joins the Saug River at Pagsabangan. Thence to the sea it is known as Tagum River which is said to be navigable for small boats for about 25 miles inland.

The Saug River, already mentioned, is navigable for barotos to Macgum.

The Tagum River, formed by the confluence of Saug and Libuganon Rivers at Pagsabangan, is navigable to this point by motor boats drawing 5 feet of water. On a much smaller scale the Tagum River and its valley is very similar to the wooded banks of the Agusan on the north coast of Mindanao.

Padada, Hijo, Sumlug, Bitanagan, Kasauman, Karaga, and Honoon are other somewhat less important rivers with a smaller volume of water, in addition to which there are innumerable small short streams and water courses that wind their way from the mountains to the sea all along the coast.

With the exception of Tagum, the rivers in Davao are of little value for transportation purposes. On the other hand the numerous falls and rapids afford rich opportunities for the construction of power plants for plantations, for industrial and lighting purposes and for transportation.

The highest mountain is Apo, 2,883 meters high, located near the Cotabato boundary, southwest of Davao; Hamihitan on the narrow peninsula south of Puhada Bay ascends to an elevation of 1,607 meters, and Latian southwest of Lais is 1,586 meters high. Several other mountains reach an altitude of 600 to exceeding 1,000 meters.

CLIMATE

In a territory so large and having the topographical formation characteristic of Davao naturally there is considerable variation in the precipitation in the various districts, but in the main Davao has a very evenly distributed and ample rainfall. In fact, the capital of the province has a more equal distribution of rainfall than any other point in the Philippines where observations are made at present and it is fairly typical of the province as a whole. The following table shows the rainfall at Davao on the gulf and in Karaga on the Pacific coast as recorded by the Philippine Weather Bureau, Manila.

TABLE X.—*Mean monthly and annual rainfall of Davao*

Months	Davao	Karaga
	Rainfall	Rainfall
	mm.	*mm.*
January	110.2	294.8
February	141.6	402.4
March	164.2	270.3
April	190.3	148.5
May	252.8	203.7
June	234.2	103.6
July	208.9	142.7
August	207.4	75.7
September	203.6	67.4
October	242.3	128.4
November	176.4	171.9
December	208.8	422.6
Total	2,340.7	2,432.0

The temperature varies, of course, with the elevation. On the lowlands it is rather warm and sultry during the day but the nights are always cool and pleasant. Further inland on the mountain slopes above 300 meters the heat is never oppressive.

POPULATION

The population of Davao is about 101,000, divided into Filipinos (the majority of whom belong to tribes peculiar to Mindanao, including the Bagobos, Bilans, Mandayans, Tagacaolos, Atas, Culamans and Moros), about 10,000 Japanese and some 300 Chinese. One hundred Americans, perhaps, are living in the province, mostly planters.

Of the native tribes the Bagobos occupy the east coast of Davao Gulf from Digos to Talomo, including the mountain slopes to Cotabato and the Guianga plain. The Tagacaolos inhabit the country from Digos to Lais, and furnish most of the native plantation labor in the province. The Culamans are scattered from Padada to Sarangani on the east coast and from Kuabo to Cape San Agustin on the west coast of Davao Gulf. The Bilans occupy Sarangani Island and the country immediately to the north thereof, and there are some also here and there in the mountains north of Cape San Agustin. The Mandayans occupy the mountain range from Cape San Agustin to Agusan and the valleys of Agusan, Hijo, and Tagum Rivers, north of the gulf. The Atas live in the interior between Davao and Libuganon Rivers. Remnants of the invading Moros are settled on Samal and Sarangani Islands, at the mouths of the

Tagum, Hijo, Lasang, and Sumlug Rivers, and in some villages on the Pacific coast between Manay and Mati.

The Japanese are occupied in growing abacá and coconuts both as owners of and laborers on plantations. The Chinese are traders.

On the face of it, from the above statement, it would appear that labor is fairly plentiful in Davao, whereas the opposite is true. The natives are either caring for their own small farms or they are occupied in other pursuits, and new estates that are opened in the future must needs import labor from the Visayas or Luzon.

HISTORICAL REVIEW

Davao is the "youngest" province in the Philippines. Its history is recent and scant and is rather in the making and in the future. But little is known of Davao prior to about 1823, until which year the Bagobos inhabited the coasts. Moro pirates then arrived and drove the Bagobos to the hills, who sent emissaries overland to the Spanish military post at Cagayan, Misamis, for aid against the Moros. As a result the Spaniards dispatched an expedition by sea to Davao, which, aided by the native inhabitants, drove out the Moros and hoisted the Spanish flag. Davao was occupied by the American army in 1900. The military government continued in force until 1914, when civil government was established and Davao was made a province in the Department of Mindanao and Sulu.

AGRICULTURAL INDUSTRIES

Reliable export figures for Davao are not available but in part may be surmised from the following table showing the areas planted to agricultural crops. Of the below named products only abacá and copra are exported.

TABLE XI.—*Agricultural crops in Davao, 1920*

Crop	Area in hectares	Yield	Value
			Pesos
Rice	4,319	[a]44,012	150,371
Coconuts (copra)	5,467	[b]875	190,774
Abacá	27,102	[b]13,009	5,206,213
Corn	896	[a]6,611	63,250
Tobacco	83	[b]10	5,476
Total	37,867		5,616,084

[a] Hectoliters. [b] Metric tons.

According to these figures, if we reduce the number of coconut trees to area, calculating 204 to the hectare, or 7 meters apart, there are 45,200 hectares planted to coconut palms in Davao, one-third of which are estimated to be in bearing. The coconut ranks first if area is considered; if crop values are the index abacá is by far the leading crop. In fact, notwithstanding its recent development Davao already ranks sixth among all the provinces in the Archipelago in abacá production, and in quality Davao abacá outranks the product of all the major abacá districts in the Philippines. By far most of the abacá is produced on plantations located around the gulf. In value of the product rice ranks second among the agricultural crops of Davao, but a large quantity of rice is still annually imported. Kateel is the most prominent rice district in the province.

The production of other crops is insignificant.

The vegetables in Davao do not differ very materially from those grown in others parts of the Philippines except that fewer kinds and smaller quantities are grown.

Sago palms, *Metroxylon sagu* Rottb., are common along the rivers and furnish a wholesome food.

Cultivated fruits are very scarce, but many wild or naturalized fruit trees, such as the Bauno, Durian and Marang, grow luxuriantly in the forest and are gathered and marketed. Citrus trees succeed well. *Citrus excelsa* var. *davaoensis* West., produces especially large and juicy fruits in great abundance.

It is but natural that abacá and coconuts should claim the attention above all other crops in Davao, and the province is unquestionably destined to become a country of large plantation ventures. Indeed, such large fortunes (for the Philippines) have been made in land speculation and abacá within such short a time that except coconuts, cattle, and to a limited extent rubber, other crops and business ventures seem to have been lost sight of.

Vegetables, fruits and poultry products command exorbitant prices, yet they are difficult, at times impossible to obtain. Of course, the major staples are profitable, but it is confidently believed that the profits from well conducted vegetable, fruit and poultry farms in Davao would be even greater and it could be started with comparatively little capital. A business venture of this kind would also be of inestimable service to the community in that it would render an isolated locality more independent of the importation of foodstuff from outside sources.

While this is true of the towns, especially Davao, it is believed that the planters also could to great advantage grow a large part of their own foodstuffs.

Lowland rice can not be recommended since its cultivation would preclude the utilization of the land for the other crops, but upland rice and corn could be grown as auxiliary crops in the young abacá and coconut plantations. Ragi, *Eleusine coracana,* one of the grain crops of India, could be used for the same purpose.

Of the legumes cowpeas and anipay, *Phaseolus calcaratus,* would be suitable for planting on a larger scale, while as vegetables the seguidilla, marutong and patani are eminently worth while. Among the root crops cassava, ubi, tongo, yautia and camotes succeed very well, and would produce abundantly. Especially is it desired to call attention to the possibilities of cassava as a table vegetable. The general impression prevails that cassava is a plant grown for the manufacture of starch only, and that the roots are quite inedible. True, the roots of most cassava varieties are hard and fibrous even in their young stage and when old they are, of course, not fit for the table. But the writer has in Bukidnon, Mindanao, eaten cassava roots boiled like white potatoes, which were entirely free from fiber, and in quality equal to young potatoes. They were greatly superior in eating quality to imported white potatoes.

Some day the Philippines, like Java, may grow her own white potatoes but in the meantime it would be eminently worth while to get familiar with the several root crops that succeed so well in these Islands, which are equally so or more palatable than the imported product, and which are readily produced.

PLANTATIONS

The rapid progress of the agricultural development of Davao may be surmised from the fact that whereas in 1917, 69 corporations were engaged in agriculture on a fairly large scale, this number increased to 127 in 1918. Of these 82 were organized by Japanese, 20 by Americans, and 19 by Filipinos.

Among these plantations those operated by the Ohta Development Company in Talomo and Mintal are the largest and are exceptionally well-organized and managed (Plates XVII *b* and XVIII). In Mintal this company has installed an irrigation system including 3 miles of main canals and 70 miles of laterals. Talomo is the center of administration of this company where it has a private wharf and large bodegas. A large, airy modern hospital of light material has been erected in Mintal and all buildings are lighted with electricity from a small hydroelectric plant at Mintal where ice is also manufactured for the needs of the plantations (Plate XIX). The plantations, which consist of abacá and coconuts, are well managed and in excellent condition. Altogether, considering area, its general appointment and management and the excellent condition of the plantations, this enterprise reflects the greatest credit on its organizers and administrators and is well worth visiting by prospective planters who wish to see a model abacá and coconut plantation managed in line with the most advanced ideas in tropical agriculture.

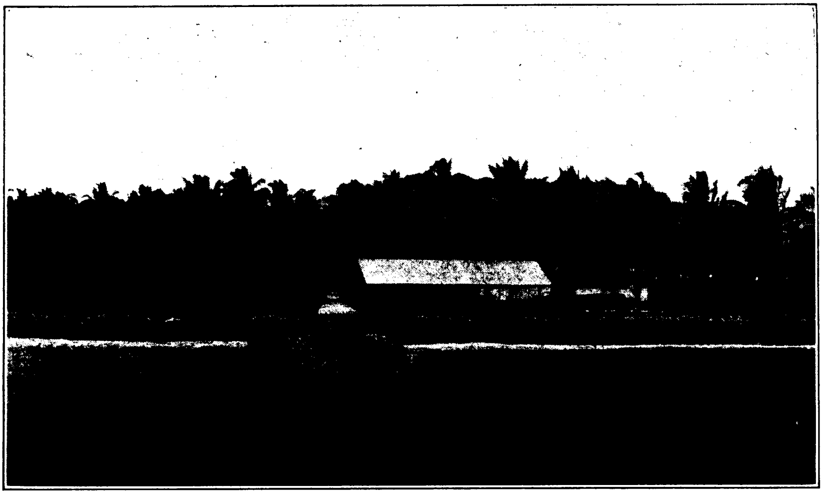
The Culaman Plantation Company at Malita also has a large plantation of abacá and coconuts in excellent condition (Plate XVII).

Among the many other plantations that have come into existence and are well established the following are especially worthy of notice: The Piso Plantation Company at Piso on the west coast of the gulf. The Madaum Plantation Company at Madaum, at the head of the gulf. The Moro Improvement and Trading Company at Tagnanan, the Gulf Plantation Company at Pantukan, and the Southern Cross Plantation Company at Pangasinan; all of which are located on the west coast of the gulf above Mapanga Bay. The Mindanao Plantation Company at Digos; the Padada Plantation Company at Padada; the Cumassie Plantation at Cumassie; the Basiaon Plantation Company at Basiaon Bay; the Lacaron Plantation Company at Lacaron and the Lais Development Company, Lais, are all located on the east coast of the gulf south of the town of Davao. These are but a few of the more prominent agricultural ventures in the province.

Nearly all the plantations in Davao are devoted to abacá or this is the principal crop, though coconuts are now being planted to an increasingly greater extent, and the indications are that very considerable areas now in abacá will be given over to coconuts. The violent fluctuations in the market price of abacá fiber coupled with the scarcity of labor is largely responsible for this movement.

At Lais and Malita some Castilloa rubber has been planted which is here considered quite promising, largely because the gathering of rubber is simple and can be performed by untrained labor. A small number of Para rubber trees have also been set out. Certainly the soil and climate appear to be very favorable for the growth of Hevea. Robusta coffee has been planted at Lais and found very successful but there are no large plantations in the province. Cattle are raised very successfully in connection with some plantations devoted to coconuts, especially near Mati.

Small areas have also been planted to lumbang or biao, *Aleurites moluccana,* for nut production by some planters, but it is very doubtful whether this crop will prove as profitable as the



(*a*) Landing and bodega of the Culaman Plantation Company (abacá and coconuts). Malita, Davao

(*b*) Road through the abacá plantation of the Ohta Development Company. Mintal, Davao

(*a*) Near view of abacá. Davao

(*b*) Abacá ready for harvesting. Mintal, Davao

(*a*) Hydro-electric and ice plant of the Ohta Development Company. Mintal, Davao

(*b*) Hospital for plantation laborers operated by the Ohta Development Company. Mintal, Davao

coconuts, abacá, rubber, and coffee, to which the province is well adapted.

RESOURCES AND PRODUCTS OTHER THAN AGRICULTURAL

The vast forests of Davao contain much the same timber trees that are found in the forests in other parts of the Philippines, such as camagon, *Diospyros discolor;* mancono, *Xanthostemon verdugonianus;* molave, *Vitex* spp., narra, *Pterocarpus indicus;* tindalo, *Cassia javanica* and *Pahudia rhomboida;* ipil, *Intsia bijuga* and *Adenanthera intermedia;* guijo, *Shorea guiso;* agoho, *Casuarina equisefolia,* and apitong, *Dipterocarpus* spp. Many other species might be mentioned.

As yet there are no saw mills to utilize the forest resources of the province.

Lumbang nuts are collected and marketed to a considerable extent. Almaciga and rattans are brought from the forest in small quantities. As yet nothing has been done to export tanbark from the mangrove swamps that are situated on the gulf.

The waters around Davao are rich in fish but the fishing industry is poorly developed.

Sulphur deposits are reliably reported to exist on Mount Apo, but no surveys have been made to determine their extent. There are hot sulphur springs at Point Baños about midway between Malita and Sarangani Channel.

TRADE AND COMMUNICATIONS

When the recent economic development of Davao is considered, coupled with the presence of an exceptionally long coastline, the reasons for the almost total lack of roads is easily perceived. The only first class road in the province has been constructed from the town of Davao to its shipping point and dock, Sant aAna, a few kilometers away, which road now is being extended to Talomo. But the absence of land transportation is not such a hardship to the inhabitants as one might be lead to believe, considering that nearly all plantations are located on the gulf and have water transportation.

Three wireless stations: one in Davao, the capital, one in Mati, and another in Malita, together with telephone lines that extend to all the more important municipalities even on the Pacific coast as far as Kateel, serve as means of communications within the province, and with the outside world.

The inter-island transportation facilities are confined to the steamers *Raritan, Fernandez Hermanos, Albay, Neil MacLeod, Yazoo, Mindanao,* and *Tablas,* of which all but the last make regular trips to Manila. These steamers not only touch at Davao and Mati, the two principal ports, but depending upon the amount of cargo to or from each place, they call at several of the plantations or municipalities in the gulf as well as on the Pacific coast as far as Kateel. These steamers also call at Zamboanga, Dumaguete, and Cebu on their way to and from Manila.

FUTURE DEVELOPMENT

The two great future industries of Davao are lumbering and agriculture.

As in Agusan and Cotabato, aside from the timber for lumbering great quantities of almaciga and rattan can be gathered in the forest while tanning extracts can be obtained from the mangrove swamps on the gulf.

The phenomenally rapid development of agricultural lands in Davao is a prophecy of the future, and this may be expected to proceed at a greatly accelerated pace. Here a word as to the development of the past may not be out of place. The progress of Davao during the last five years undeniably has been more rapid than that of any other province in the Philippines. Many (for the Philippines) big corporations have been organized and have set out plantations of abacá and coconuts. There has been a great stampede for plantation sites, and an impression has recently gained headway that the public land in Davao was fast becoming exhausted. This is not true. How erroneous this belief is may be seen by a glance at the figures on the first page of the within article, where it will be noted that less than 2 per cent of the lands of the province are claimed for agricultural crops. It is a fact, however, that the agricultural lands near the coast are rapidly being occupied and since there are practically no roads into the interior of the province, planters away from the coast naturally are at a great disadvantage. In fact large areas of the most fertile lands in the province away from the coast are practically inaccessible to planters who would unquestionably open up the lands if the communications with the coast was established. This brings to the fore the future transportation problem of Davao.

The long coastline will permit extensive employment of water transportation on the gulf by small craft, for which there is good anchorage at many points. Good roads from these minor "ports of call" into the interior would do much to bring several of the inland districts within the region where agricultural development is feasible, but for the opening up of the great agricultural district in northern Davao and the establishment of communications with the neighboring provinces, railroads are

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imperative. With a view of serving the agricultural interests of Davao a harbor more centrally located would have been desirable, but all other advantages are so one-sidedly possessed by Malalag Bay in contrast to other points that one may expect it to become the principal shipping port in Davao.

Malalag Bay (Plate XXI) has not the uniquely favorable combined features of Parang, Cotabato, but:

(1) The bay is well protected; vessels would be safe there no matter how rough the gulf, yet,

(2) It is large enough to accommodate a large fleet.

(3) The water is deep close to the shore and piers could be constructed at a comparatively slight expense.

(4) The topographical features of the country surrounding the bay are favorable to the growth of a large and attractive city under good sanitary conditions.

(5) An abundant supply of excellent water is obtainable from the Padada River when the port shall have expanded into a large city, and during its infancy the flow of the Malalag River will be more than ample.

(6) While Malalag is located at the lower end of one of the large agricultural regions of Davao, it is next door to another great agricultural section of the Cotabato Province.

A railway then, terminating at Malalag, (one branch turning westward and crossing the range of mountains would enter the Cotabato Valley) should run northward through the rich valleys of Padada, Digos, and Santa Cruz in succession, then penetrate the Guianga Plain to turn in a northeasterly direction until it entered the Agusan Valley territory to connect with the railroad from Nasipit. For an outlet to the sea in the northern part of the Davao Gulf, Hijo would probably be the most desirable point, though low and swampy. A third roadstead at Mati on the Pacific coast will probably be established eventually for a branch line penetrating the interior of the peninsula to the north of this town, to join the "Hijo–Nasipit" line near Compostela.

Davao is well adapted to a wide range of crops. Coconuts and abacá are already so extensively planted and have proved so eminently successful as to require no further comment except that the area planted to the coconut palm is likely to increase at a much greater rate than that of abacá, especially until the present scarcity of labor is relieved or a practical hemp stripping machine is invented and placed the market. A successful mechanical hemp stripper would release a great number of laborers from the tedious process of stripping hemp by hand for other plantation work and would unquestionably do more to increase the acreage planted to abacá than any other event except the admission of foreign labor.

The quality of the soil and the rainfall indicate that large areas of land in Davao are well adapted to Para rubber. It is true that the earliest attempts to grow Para rubber in Davao failed, but this would appear to have been due to faulty seeds and plants, and to inexperience in handling rubber, for later plantings have done well. Also, one may expect Para rubber in time to become one of the principal products of Davao. Notwithstanding the progress made by Castilloa in Davao, in the light of the experience with this rubber in all other regions where it has been tried, it can not be recommended as a plantation crop where Para rubber will succeed.

While Arabian coffee is not recommendable anywhere in Davao, there is every reason to believe that the new blight resistant coffees would prove highly successful. More particularly on the Guianga plain tea culture on a large scale would appear feasible.

On some of the lighter soils tobacco of good quality might be produced. Other annual crops adapted to this regions are jute and roselle for fiber. Small quantities of anabo fiber are already produced from a native plant, *Abroma augusta,* and it is by no means impossible that this might become an important agricultural crop, for the fiber is of good quality and the plant is of rapid growth and easily grown. Cassava starch in large quantities might be produced. The production of the annual crops is largely a question of securing enough labor to handle them.

The food plants grown in other parts of the Philippines succeed well in Davao and with the proper organization of its agricultural industries the province could be self-supporting so far as foodstuffs are concerned.

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LANAO

GENERAL DESCRIPTION

The Province of Lanao (Plate XXII) is located between 123° 35′ and 124° 51′ east longitude, and 8° 35′ and 7° 25′ north latitude on the Island of Mindanao, and is bounded on the east by Bukidnon, on the south by Cotabato and Illana Bay, on the west by Zamboanga, and on the north by Pañgil Bay, Iligan Bay, Misamis, and Bukidnon. It has an area of 2,439 square miles and a population of 91,443 inhabitants. By way of comparison, it may be noted that while it is the smallest province in Mindanao, yet Lanao is larger in area than the State of Delaware, which is 2,050 square miles in extent.

According to the Bureau of Forestry 65.4 per cent, 412,890 hectares, of Lanao is commercial forest, 7.9 per cent, 50,730 hectares, is open land or covered with cogon, 19.7 per cent, 124,006 hectares, is still unexplored territory; and only 1.5 per cent, or 9,090 hectares, is under cultivation.

Lanao derives its name from Lake Lanao, which name is the Maranao equivalent for "lake." This lake is located about 660 meters above sea level and is about 18 miles long and 16 miles broad at its greatest width, and is said to cover an area of approximately 200 square miles.

With the exception of a comparatively narrow strip of land on the coasts, Lanao is a highland country with a series of valleys and plateaus, rising to an elevation of about 900 meters at Lake Dapao, well watered by numerous rivers and streams.

The more noteworthy mountains include Mt. Butig, south of Lake Lanao, 2,250 meters high; Mt. Gurain about 2,100 meters high, west of the lake; Mt. Inlaoan rising from the shores of Nunungan to a height of 1,585 meters; and the Kapay mountains in northeastern Lanao. Mount Piapayungau on the Cotabato border, is about 2,770 meters high. West of this mountain rises the extinct volcano Ragang to an altitude of about 1,650 meters, about which are many streaming vents, though the crater itself is grass-grown and shows no signs of recent eruptions.

The Agus, the outlet for Lake Lanao, is the largest river in the province. With its large volume of water, its numerous falls and rapids Agus is a potential source of water power of great importance. The Mataling, emptying at Malabang, is the second most important river and through one of its tributaries drains Lake Dapao. Mandulug emptying into Iligan Bay, a short distance northeast of Iligan, is the longest river in the province. Several small rivers drain the Lanao basin east of Lake Lanao and so augment the Agus. Numerous other small rivers and streams drain the remainder of the province, flowing to the coasts both in the north and south.

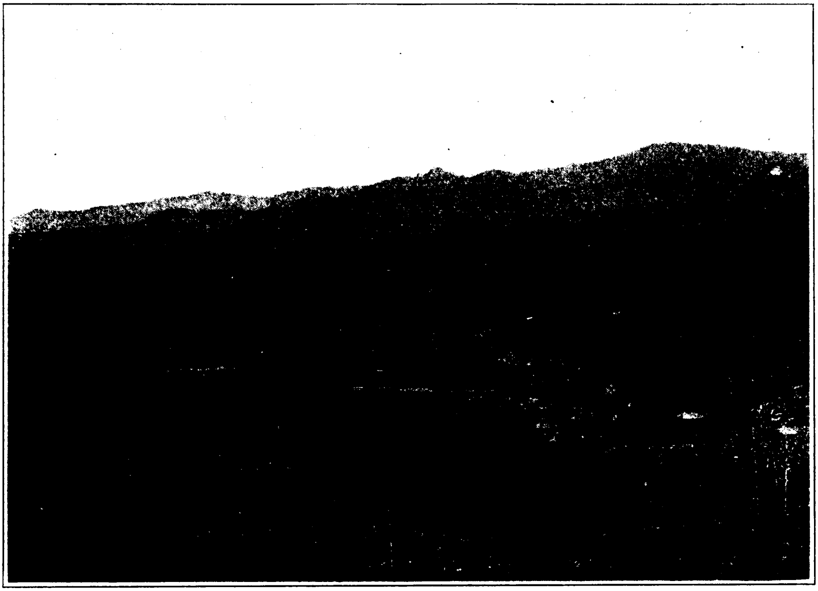
Aside from Lanao, there are several small, very attractive lakes at varying elevations, such as Butig, Dapao, Nunungan, Talao, Dagayuñgan, and Uyaan. In passing it may be said that while native fish are found in the lakes and rivers, black bass have been introduced into Lanao and carp into Nunungan and Dapao.

The single most impressive feature of Lanao Province is Lake Lanao, apparently a gigantic extinct crater located in the center of the province, surrounded by undulating grass-covered plains and valleys, with here and there mountains rising from the plain. Most of the population are settled in the Lake Basin.

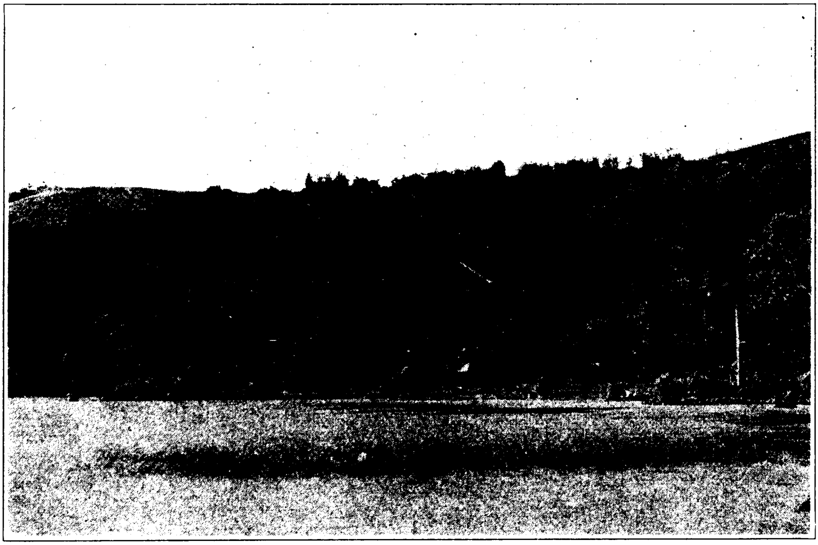
Lanao is well worth a visit by the traveling tourist, because of the scenic beauty of the lake country, the beautiful Maria Cristina Falls on the Agus River and the interesting native population.

The lake is best approached by auto from Iligan on the north coast over the excellent, well maintained road, at first skirting the sea and then passing through Camp Overton, the base of the military operations against the Moros during the early days of American occupation, but now abandoned. Here the road makes an abrupt turn to the south and begins a steady climb to the lake. The Maria Cristina Falls, 68 meters high, and the largest in the Philippines, may be reached a few kilometers from Camp Overton. The road winds its way here through virgin forest, there through undulating hills, and again hugging the precipitous mountain side, with now and then glimpses of streams and rivers, through cultivated fields and by picturesque Moro homes, until one ascends the rim of the old crater lake, when the country below spreads out in a beautiful wide, map-like panorama. (See Plate XXIII.) Then a kilometer or two upward and on the other side there is the glittering lake, set in a frame of green, billowy plains with towering mountains in the distance. To the right is Camp Keithley and proceeding across the Agus River as it leaves Lake Lanao, one reaches Dansalan, the provincial capital, attractively located on the lake shore.

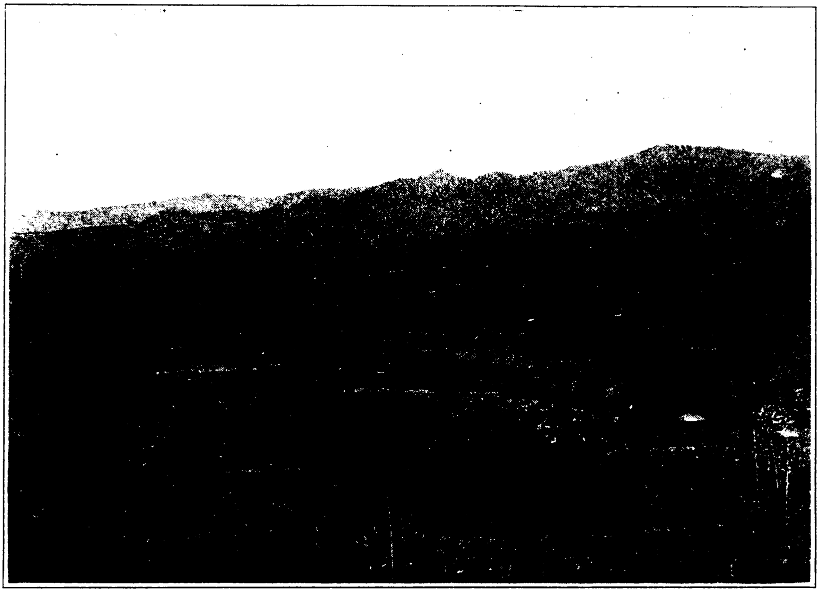
Dansalan is the southern terminus of the first class road but interesting trips can be made from here on Lake Lanao by



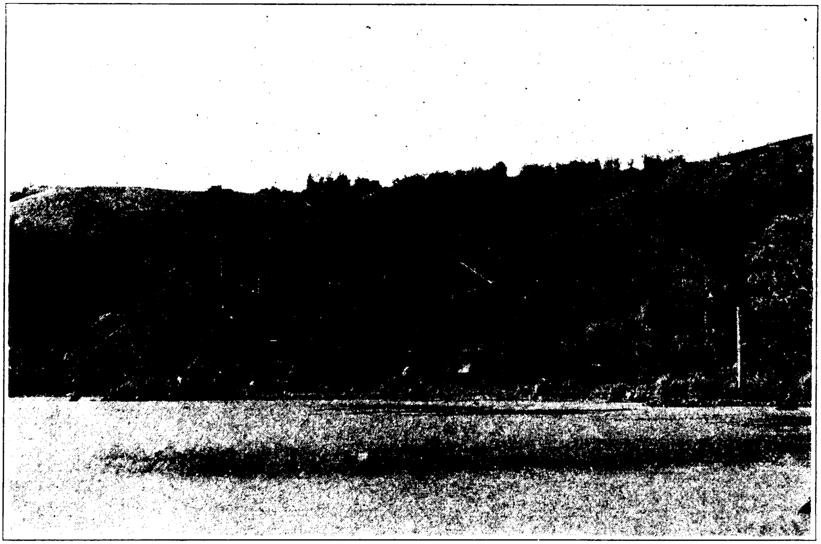
(*a*) Typical view of the settled region near Lake Lanao



(*b*) Typical view of the shore line of Lake Lanao at Ganasi



(*a*) Typical view of the settled region near Lake Lanao



(*b*) Typical view of the shore line of Lake Lanao at Ganasi

PLATE XXIV

(*a*) Giant bamboos on the road from Ganasi to Lake Dapao, Lanao

(*b*) Vegetation on the shore of Lake Dapao, Lanao

launch, of which there are several in service on the lake, to the various settlements on the lake shore, Tamparan, Ganasi, and Uatu being the most important. Lumbatan, too, is interesting and worth visiting because of its agricultural school.

For those who may wish to go overland to the south coast of Lanao there is an interesting horse trail from Ganasi to Malabang. Starting at Ganasi this road leads through a hilly, sparsely populated country, alternately passing through cogonales, patches of secondary jungle, and large clumps of a tall, spineless bamboo locally known as "buntong," steadily ascending until Lake Dapao is almost reached, a small but very pretty body of water. Stands of tall dap-dap trees, *Erythrina indica,* passed now and then mark small coffee "plantations" of former days. These trees are quite picturesque and striking during the leafless and flowering seasons, and reach astonishing dimensions as compared with those commonly seen on the lowlands. Apparently they have here found an ideal home.

Nowhere in these Islands is tropical vegetation more opulent than at this mountain lake with its attractive pandans, (Plate XXIV *b*) graceful tree ferns and large groves of giant bamboos, the latter by far the biggest in the Philippines. This bamboo, a spineless and still unidentified species, is found already a short distance from Ganasi, traveling to Dapao, and it also grows in the highlands of Bukidnon though in the climate of Dapao it seems to reach its maximum development. (Plate XXIV *a*.)

Shortly before reaching Lake Dapao the road begins to descend, and the descent is still more pronounced after one leaves Dapao for Malabang. The road here passes through a virgin forest which is practically unexplored botanically. The rainfall is heavy and of equal distribution and the soil is a light, very fertile volcanic ash rich in humus on the southern exposure of the mountain range.

Malabang, on the south coast, is interesting because of its old forts, erected by the Spaniards, and still in good repair, and its large springs of clear, cold water.

The soil in Lanao is exceedingly fertile, and as a whole the land is much superior to Bukidnon for agricultural purposes. Nowhere a heavy clay so far as seen, in general the soil is of a more compact texture in the northern part of the province, traveling from Iligan over Dansalan to Malabang. The land on the south of Lake Lanao, from Lumbatan, to Madalum around the southwestern corner of the lake is very light and permeable, which is characteristic also of the land on the trail from Ganasi over Lake Dapao to Malabang.

CLIMATE

While the climate on the coasts is warm and sultry, in the interior highlands it is cool and pleasant, though the rains are rather too plentiful for comfort.

Except for those following, kindly furnished by the Director of the Weather Bureau, Manila, rainfall records for Lanao are lacking.

A few miles inland from the north coast to an elevation of perhaps 250 meters, the average rainfall is probably not more than 1,800 millimeters annually, but this is quite equally distributed, with the least rain falling from January to May. With the rising elevation the precipitation increases in volume until on the plateau lands and valleys in the interior it is possibly 3,000 millimeters. The rainfall in the interior is abundant at all times of the year. Near the south coast the rainfall probably approximates 2,500 to 3,000 millimeters annually, well distributed throughout the year, judging from the character of the vegetation and the rainfall records of Tukuran, Zamboanga, also furnished by the Director of the Weather Bureau.

TABLE XII.—*Rainfall in Lumbatan, Lanao*

Month	1917	1918
	mm.	*mm.*
January	161.3	370.4
February	164.2	237.5
March	231.1	183.0
April	365.5	461.5
May	282.5	265.4
June	469.5	508.0
July	191.6	259.1
August		82.6
September	156.9	
October	437.4	374.7
November	185.4	124.4
December		

TABLE XIII.—*Rainfall at Tukuran, Zamboanga*[1]

Month.	1917	1918
	mm.	*mm.*
January	55.1	404.8
February	70.6	0.0
March	76.7	
April	248.2	127.0
May	434.6	241.9
June	195.5	421.6
July	130.4	303.3
August	320.3	806.3
September	192.3	186.4
October	405.8	277.5
November	170.9	218.9
December	361.7	
Total	2,662.1	

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[1] Tukuran is located in Illana Bay in Zamboanga near Lanao boundary.

See also the rainfall records from Buldun and Kabasaran quoted in the descriptive article of Cotabato in the previous issue of this REVIEW.

POPULATION

Of the 91,443 inhabitants, according to the Census of 1919, some 80,000 odd are Maranao Moros, found throughout the province. They are a robust, strong and warlike people and are notably energetic, intelligent and industrious, and for a long time successfully resisted invasion. They are occupied principally in farming and fishing, and their farms in the interior are remarkably well managed considering the degree of culture and the primitive tools of the people. The Maranaos make good plantation laborers, but they cannot be depended upon as a labor supply for development work since they mostly own and till their own farms. There are some 6,000 Visayan settlers living principally on the north coast of the province, trading farming and fishing. About 2,000 Manobos live in the northeastern corner of Lanao adjacent to Bukidnon. Some 150 Americans live in Lanao. As in other provinces in the Philippines most of the local import and export trade is in the hands of Chinese. Japanese are found here and there.

HISTORICAL REVIEW

The authentic written history of Lanao is scant.

The Spaniards first penetrated to the lake region in 1639, bringing six boats from Iligan, but later retreated to the coast as the result of renewed hostilities by the Moros. They did not again approach the lake for a period of about 250 years. Active operations against the Moros were again begun in 1890. Malabang was permanently occupied the following year, and an expedition penetrated to Lake Lanao from the south, and four gun boats were placed in commission on the lake within the next few years. The Americans occupied Iligan in 1900, and penetrated to the lake in 1902. Civil Government was established and Lanao made a province in the Department of Mindanao and Sulu in 1914.

AGRICULTURAL INDUSTRIES

Agriculture is the principal industry in Lanao, and while it is carried on in a limited way, the native farmer in Lanao is far in advance of his compatriot in the neighboring provinces of Bukidnon and Cotabato.

Rice, coconuts, and abacá are the principal crops, but corn, coffee, sugar cane, cassava, camotes, gabi, cacao and bananas, and various vegetables and fruits are grown to more or less extent. A mall quantity of tobacco is also grown. The following statistics, presents a picture of today's agricultural development.

TABLE XIV.—*Agricultural statistics of Lanao, 1920*

Crop	Area in hectares	Yield	Value
			Pesos
Rice	3,661	[a] 43,473	418,320
Sugar cane (sugar)	182	[b] 140	55,341
Coconuts (copra)	880	[b] 199	65,570
Abacá	447	[b] 87	28,213
Corn	1,750	[a] 18,741	156,759
Tobacco	82	[b] 28	9,045
Total			

[a] Hectoliters. [b] Metric tons.

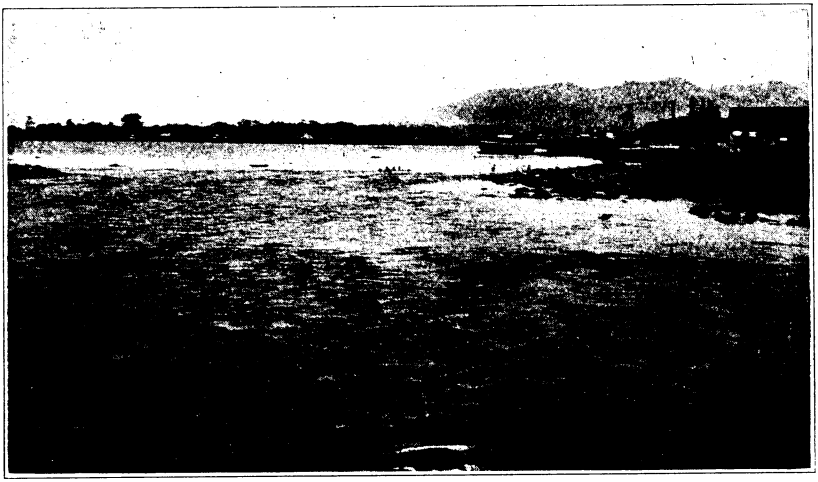
Lowland rice is the most important crop and is produced mostly in the valleys on the western shore of Lake Lanao about Taraka and Ramain, that are estimated to have about 8,000 hectares of excellent rice land. Upland rice is also extensively cultivated and produces well. With the exception of Cotabato, Lanao is the only province in Mindanao which is self-sustaining in respect to rice and it also exports minor quantities of this grain when the seasons are favorable for the crop. The rice industry is capable of great extension, especially that of upland rice, and rice could easily become an export crop of no mean importance in Lanao.

The now most important money crop for export is copra. At present most of the copra is produced on the north coast where planting began earlier than on the south coast and it is still in the lead though the south coast is rapidly gaining in the area planted. All the coconut plantations on the norh coast are in the form of small holdings, while on the south coast a few modern plantations of considerable area have been set out about Malabang, the largest of which is reported to have some 40,000 trees. These plantations are all of recent origin and the oldest are just coming into bearing. (Plate XXV *b*.)

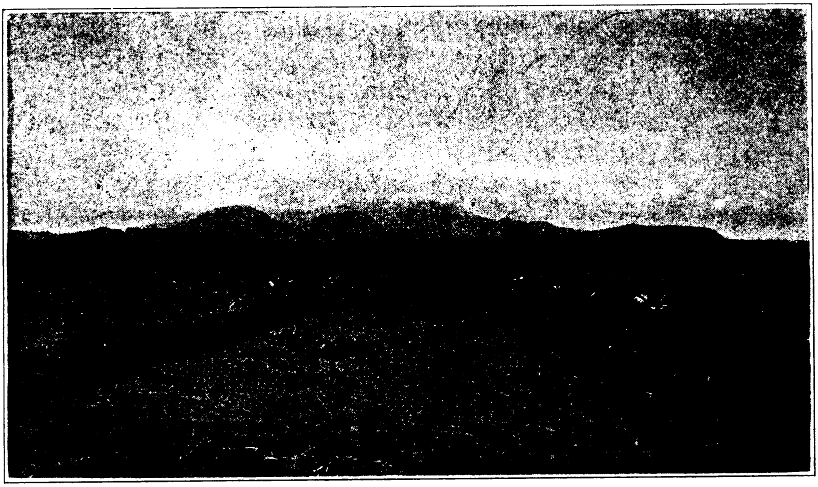
The soil and climate in the wide lowland belt along the coast is well adapted to coconuts and large areas may be expected gradually to be planted to this crop.

As yet abacá is of relatively little importance but the area planted to this crop, which is well adapted to native culture, is slowly increasing even in the interior.

Before the entrance of the Hemileia into the Philippines, Lanao was famous for its coffee, of which fairly large quantities were exported from Iligan and Malabang, and the traces of this industry are still visible everywhere in the highlands in the dap-dap groves in which the coffee (Arabian) was planted. But,



(*a*) Lake Lanao from the bridge over Agus River. Camp Keithley to the right



(*b*) Coconut plantation near Malabang, Lanao

aside from the attacks of the coffee rust, the industry was further demoralized during the Spanish and American campaigns against the Moros and very little coffee is produced now. As a matter of fact, owing to the excessive rains, Lanao is not well adapted to Arabian coffee, the planting of which is not advisable. The cropping of the new rust resistant coffees is not adversely affected by heavy rains, and these coffees, which have already been successfully introduced, unquestionably have a bright future in the province.

Corn and sugar cane are grown to a slight extent at the low elevations near the north coast. Camotes are grown very successfully and are together with rice and cassava the principal food staple of the Moros. At an elevation of 600 meters and above the white potato has been found very successful when properly handled.

Most tropical vegetables found in other parts of Mindanao are also grown in desultory fashion in Lanao. The temperate vegetables succeed well at the higher elevations.

Among the little known or noteworthy fruits it may be of interest to know that the bauno has not been found above an elevation of 450 meters.

A "bauno forest" is said on good authority to exist near Momungan, about 330 meters above sea level. The durian trees attain very large dimensions in the rich, friable, volcanic soil on the south coast of Lake Lanao, and trees exceeding a meter in diameter and 25 meters in height are common at an elevation of some 675 meters. The marang trees still grow large and vigorous up to 900 meters altitude.

The Moros distinguish the following mango varieties: Dudul, Kagapas, Titi, Madum, and Bagitan of which the last one is said to be a rare variety found only at Uatu, the fruits as large as a papaya, sweet and fine flavored and devoid of fiber. Among the bananas the Borongan is a large fruit of excellent eating quality deserving wide distribution in other parts of the Philippines.

NATURAL RESOURCES AND PRODUCTS OTHER THAN AGRICULTURAL

The forests constitute an important source of wealth in Lanao. Because of their accessibility the most valuable forests are those located in the northwestern part of the province, and on the mountain slopes facing Illana Bay. Another large forest covers the mountains along the Bukidnon border descending into the Lake Lanao basin. This forest is so difficult of approach that it will probably remain in its primeval state for a long period. It should, however, for this very reason continue to prove a valuable source of almaciga and bejuco. One lumber company has obtained a large concession in the northwestern part of Lanao with headquarters and sawmill in Kolambugan. (Plate XXVI.) The forest contains the same timbers found in other parts of Mindanao.

About two miles from Lake Lanao in an easterly and south easterly direction, the land rises abruptly and forms a rolling plateau approximately 300 square miles in extent, at an elevation of from 900 to 1,650 meters, which is heavily forested with excellent hardwoods.

Bejuco (rattan), almaciga, and beeswax is collected in the forest in small quantities which could be readily increased.

Adjoining the excellent agricultural lands from Katapagan southward there is a nipa swamp, *Nypa fruticans,* some 9,000 hectares in extent on Pañgil Bay, reliably reported to be the largest in the Philippines, exceeding in area the large nipa swamps in Bulacan and Pampanga on Manila Bay. The vigor of the plants in this virgin swamp, which has never been exploited, is extraordinary. With the rapid growth in popularity of farm tractors, and the increased demand for motor spirits the cost of which is steadily mounting, it would seem that here lies an undeveloped source of fuel in the form of alcohol of very great extent and value, and that adjacent to an exceptionally large body of excellent agricultural land.

Gold, silver, copper, and coal are known to exist in the Kapay mountains, but a geological survey has never been made and the extent of the deposits is not known.

An abudance of fish is available on the coasts but no fisheries have been developed.

TRANSPORTATION AND COMMUNICATIONS

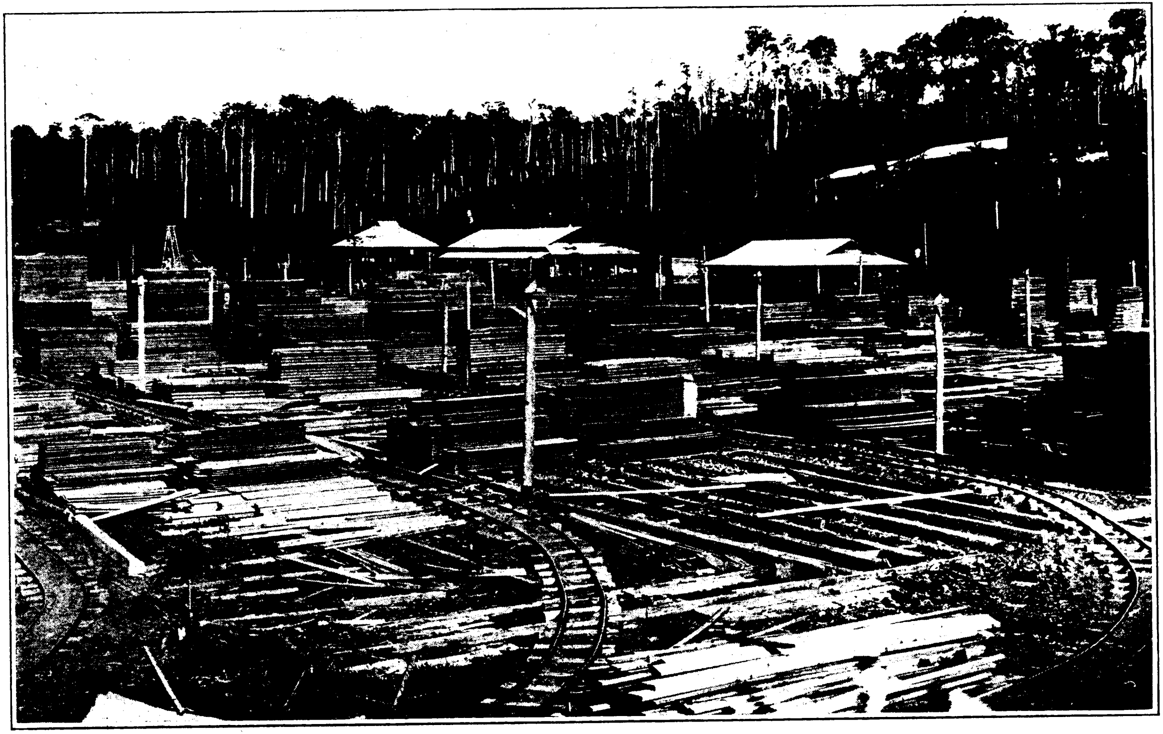
Lanao has connection with the outside world by the means of small steamers from Cebu which make weekly calls at Iligan. The *S. S. Tablas* calls twice monthly at Iligan and Kolambugan on her way from Zamboanga to Butuan, stopping also at several other towns on the coast. On her way between Zamboanga, Cebu and Manila, the *S. S. Mindanao* makes occasional stops at Iligan and Kolambugan. The *S. S. Research* on her trips between Zamboanga and Cotabato at times makes Malabang a port of call.

Malabang has a wireless station, and Iligan has cable connection with Cebu. The interior of Lanao is served by a local telephone system connecting all the more important points.

Iligan and Dansalan are connected by a first class road approximately 31 kilometers long.

Lake Lanao forms an important means of communication in the interior, and one steam and a small number of motor launches

PLATE XXVI



Lumber yard in Kolambugan, Lanao

are in operation on the lake between Dansalan and Ganasi and intermediate points, aside from numerous native sailing craft. From Malabang there is a good trail to Ganasi, and several other trails connect all the other settlements which thus can be reached on horseback. During the military régime good wagon roads were constructed from Malabang to Ganasi and Lumbatan, but these roads have not been maintained and have reverted to horse trails.

TRADE

The import and export trade of Lanao is conducted through Iligan and Malabang. The lumber is shipped from Kolambugan.

Copra, lumber, and abacá constitute the principal exports of Lanao, but rice, corn, coffee, mats, camotes, bejuco, almaciga, beeswax, cattle, and marine shells are also exported in small quantities. The export of all could be greatly increased given the proper impetus.

PROSPECTIVE INDUSTRIES AND DEVELOPMENT

As may be gathered from the foregoing the industries of Lanao are destined to become chiefly agricultural. Lumbering for many years will continue to remain of considerable importance and when properly organized an alcohol distilling industry of large proportions should grow up.

The greater part of the land in the Lake Lanao basin is already occupied by Moros. Still, there are considerable bodies of good agricultural land available for settlement by the immigrant of moderate means—for instance in the Taraka Valley, especially adapted to rice, and the districts around Lake Butig and Dapao, suitable for rice, potatoes, coffee, and tea. Munay also has a fine body of agricultural land open for settlement well adapted to coffee and rice. Until the more remote regions shall have been reached by good roads the more accessible lands near the sea coasts, those on the road from Iligan to Dansalan and the valleys near the shore of Lake Lanao, are preferable for such settlements. There is abundant room for immigrants on the fertile agricultural lands on the mountain slopes facing the coasts on the cogonales and the secondary forest land which is easily and cheaply brought under cultivation.

Crops adapted for the small farmer of this type are coconuts, coffee, abacá, rice, and peanuts; and corn in the drier districts on the north coast. On the light soils at the southern end of the lake basin, potatoes of excellent quality can be, and unquestionably some day will be produced on a large scale for exportation to other parts of the Philippines,—when there are better and cheaper means of transportation.

For big capital there are first the forests on the mountain slopes facing Illana Bay available for exploitation. But as in Agusan lumbering itself should be but the preliminary step in developing this country into large coconut, rubber, coffee, and tea plantations. Other crops will be remunerative, but it is believed that here the conditions are more favorable for the development of a big tea industry than anywhere else in the Philippines. The rust resistant coffees of the Robusta type should also find ideal conditions here.

The largest body of agricultural land is located south of Kolambugan, over Katapagan to the divide of the watershed between Pañgil Bay to the north and Illana Bay to the south.

This land is exceedingly fertile, of gentle slopes, rising from the sea coast, and is drained by numerous rivers. It is unquestionably one of the most attractive locations not only in Lanao but in the whole Island of Mindanao for the opening up of large plantations ventures. Aside from enormous tracts of grazing land in the foot hills to the east and south, the first class agricultural land in this area is conservatively estimated to not less than 60,000 hectares. Sugar cane might be grown on a large scale and there is abundant room for big rubber and coconut estates.

As a matter of fact, a project was organized by the Spaniards with a view of colonizing this district many years ago, but the early pioneers were unable to remain because of the repeated attacks of the hostile Moros and the project finally was abandoned. A herd of wild carabaos descended from those abandoned by the Spaniards is all that remains of the adventure.

Another attractive district for development on a big scale is the valleys drained by the Maridigao and Malitabug Rivers and their tributaries in the southeast of the province, with outlet at Parang. Other desirable sites are located around Lake Dapao, at Lake Butig, at Munay and Taraka.

Lanao does not possess pastures comparable in size with the tremendous areas in Cotabato and Bukidnon, but they merely seem small in comparison. In reality they are large.

With its many natural advantages, Lanao lacks a really good harbor such as the Nasipit in Agusan, Malalag in Davao and Parang in Cotabato. For a large port Kolambugan (Plate XXVII) has greater advantages than any town on the coast and may some day become a railroad terminus of some importance though the superior advantages of Parang in Cotabato will inevitably attract the commerce of southern Lanao and possibly of the entire Lake Basin in the interior of the province.

Oversized
Foldout

MISAMIS

GENERAL DESCRIPTION

The Province of Misamis is located between 123° 33′ and 125° 13′ east longitude, and 8° and 9° 15′ north latitude, including the narrow coastal plain and the mountain slopes facing the sea north of Bukidnon; the large plain and the mountain chain west of Pañgil and Iligan Bay on the Island of Mindanao; and the Island of Kamigin. It has an area of 1,020 square miles, approximately one-half the size of the State of Delaware and has a population of 198,981 inhabitants. Forty-eight per cent, or 127,902 hectares, is virgin forest; 5.7 per cent, 15,205 hectares, is mangrove swamp; 2.7 per cent, or 7,214 hectares, is covered with cogon and other grasses; 40.4 per cent, 107,690 hectares, still remains unexplored. Only 3.1 per cent, 8,244 hectares, is under cultivation, according to the Bureau of Forestry.

The coast north of Bukidnon is indented by two large, open bays, but lacks good harbors for port development of which the best is Cagayan, referred to in the discussion of Bukidnon. The tillable land here consists of a narrow coastal plain, beyond which the mountains rise to the Bukidnon plateau some 300 meters high. The western part of Misamis, facing Pañgil and Iligan Bay, is in the main a large fertile plain rising slowly to a mountain chain stretching from north to south, of which Mount Malindang, with an elevation of about 2,400 meters is the most prominent peak. While the adjacent low, swampy country leaves much to be desired for a town site, Misamis has a good anchorage and is the logical place for the construction of a port through which the products of Misamis may be exported when the rich agricultural lands in this part of the province shall have been developed.

Numerous small streams and rivers find their way from the interior of Mindanao to the sea, none of which is important. The Cagayan River is the largest and is navigable for small crafts a short distance inland from the coast.

CLIMATE

The rainfall on the coastal plain north of Bukidnon is moderate, with most of the rain falling from June to including November, as may be seen from the following table.

There are no rainfall records for that part of Misamis lying to the west of Iligan Bay, but it is well known that the precipitation is fairly evenly distributed, with no pronounced dry period and with a probable mean average rainfall of 2,000 millimeters per annum.

TABLE XV.—*Mean monthly and annual rainfall in Misamis*

Months	Cagayan	Balingasag
January	51.7	75.2
February	40.7	51.7
March	38.1	25.6
April	34.1	21.3
May	98.2	47.8
June	198.2	177.8
July	152.8	241.0
August	185.1	179.0
September	192.5	274.4
October	162.5	225.9
November	77.8	253.6
December	122.6	86.2
Total	1,354.3	1,659.5

POPULATION

The original inhabitants of the coast land north of Bukidnon were Bukidnons and Manobos, but they were driven back into the interior with the arrival of the Visayans from the Islands to the north. The Spaniards first settled and began the Christianization of the natives near Cagayan in 1622, and gradually extended their influence along the coast until the entire province passed under their dominion and control.

At present the population numbers 198,891, and is principally Visayan with the usual sprinkling of Chinese traders in the coast towns. Quite a number of Spaniards have remained since the days of Spanish dominion, but few Americans have settled in the province.

AGRICULTURE

A considerable part of Misamis is already under cultivation, but the greater part of the tillable land is still open for settlement. The narrow strip of level land north of Bukidnon and the steep mountain sides in the rear preclude the extension of the cultivable area here. But the fertile plain west of Iligan and Pañgil Bays offers exceptional opportunities for agricultural development, within easy reach of a good harbor at Misamis, to which a railroad could be constructed at a minimum of expense and maintenance, and it is near Cebu and Iloilo. One may expect this large country eventually to develop into large sugar and coconut plantations, and Misamis could readily be made a port of entry for large ocean going vessels to carry produce direct to America and Europe without extra cost for transhipment.

The following statistics show the present agricultural development of Misamis.

TABLE XVI.—*Agricultural statistics for Misamis, 1920*

Crop	Hectares	Yield	Value
			Pesos
Rice	8,354	[a] 144,741	1,130,446
Sugar cane (sugar)	71	[b] 121	42,968
Coconuts (copra)	24,025	[b] 36,209	12,181,011
Abacá	14,039	[b] 5,625	2,205,286
Corn	24,846	[a] 369,208	3,286,760
Tobacco	490	[b] 72	39,910
Total	71,825	----------	18,886,381

[a] Hectoliters.

[b] Metric tons.

MISCELLANEOUS INDUSTRIES

A small lumber mill is located in Misamis which could be considerably enlarged for the exploitation on a large scale of the forests on the monutain range west of the plain. And the forests also could be made to yield considerable quantities of rattan and almaciga. A cutch industry could be developed in the mangrove swamps which later might be planted to nipa palms for alcohol production.

Finds of coal, gold and sulphur have been made on the Islands of Kamigin but little is known of the extent of the deposits.

TRANSPORTATION AND COMMUNICATIONS

Steamers from Manila call at Cagayan and Misamis, and small steamers from Cebu and Zamboanga in addition to the two ports mentioned also call at Oroquieta, Jimenez and Balingasag at regular intervals to take care of the local import and export trade. Local telephone system connect the coast towns and there is a cable to Cebu connected with Cagayan, Misamis, and Jimenez.

SURIGAO

GENERAL DESCRIPTION

The Province of Surigao is located between 8° and 10° 30′ north latitude, and 125° 23′ and 126° 28′ east longitude, in northeastern Mindanao. It is comprised of the eastern mountain slope north of the eighth parallel, the northern tip of the Surigao peninsula of Mindanao, and several islands north of the mainland, of which Dinagat and Siargao are the largest. Surigao is bounded on the south by Davao, on the east by the Pacific Ocean, on the north by Surigao Strait, and on the west by the Mindanao Sea and Agusan Province. Surigao has an area of 2,888 square miles, and a population of 122,022 inhabitants.

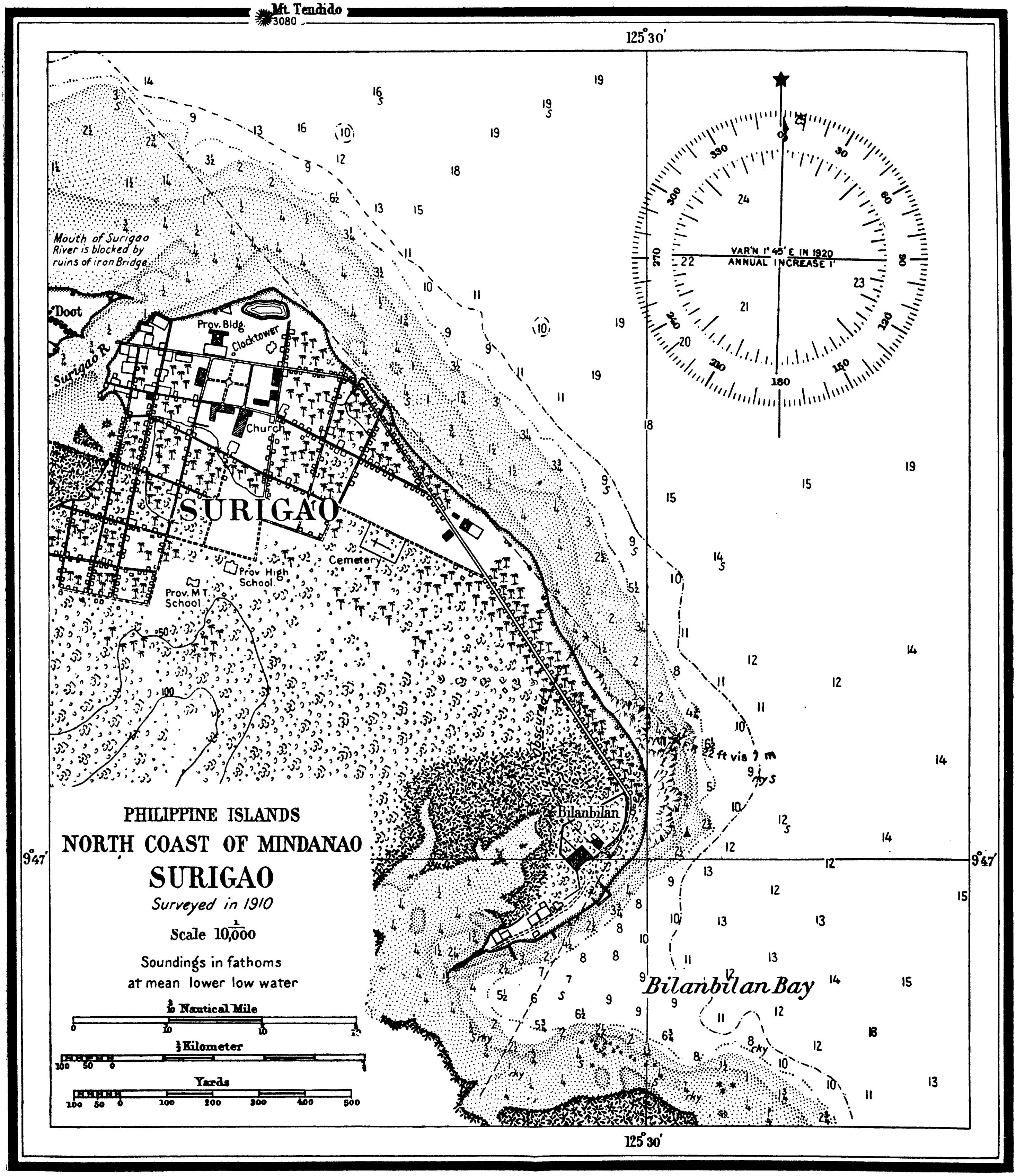
According to the surveys made by the Bureau of Forestry in 1919, 73.3 per cent, 548,406 hectares, is commercial forest; 1.4 per cent, 10,610 hectares, is in cogon; 2.5 per cent, 15,205 hectares, is mangrove swamps; 5.6 per cent, 41,825 hectares, is under cultivation; 14.1 per cent, 105,550 hectares, still remains unexplored.

Topographically Surigao is a broken, mountainous country with comparatively little agricultural land. The rivers are small and unimportant. The Tago and Cantilan are the largest. Lake Mainit, believed to be the crater of an extinct volcano, between Agusan and Surigao, is a beautiful sheet of water, with several hot springs nearby.

The Pacific Coast is indented by several large and small bays, of which Lianga and Lanuza Bays are the largest and most important. In the event that a railroad is constructed from Nasipit to the Davao Gulf along the route suggested in this publication, it will probably be found expedient also to extend a branch line from Azpitia in Agusan to Lianga Bay.

CLIMATE

The rainfall is heavy, with no dry period, though there is appreciably less rain from June to September. For comparison with the following table from the extreme north of Surigao on the mainland, see also the rainfall of Karaga in Davao which is probably representative of condition in the northern part of Surigao.



MAP OF SURIGAO

TABLE XVII.—*Mean monthly and annual rainfall in Surigao*

Months	Rainfall
	mm.
January	484.6
February	342.0
March	296.8
April	220.3
May	137.8
June	131.8
July	133.6
August	93.3
September	151.0
October	239.2
November	401.1
December	552.2
Total	3,183.7

Surigao is closer to the path of the typhoons than any other province in Mindanao, and while the damage they inflict there is not comparable with that done further north, now and then it is considerable.

POPULATION

Surigao is peopled almost entirely by Visayans who have drifted down from the islands to the north. There are also a few Manobos, Negritos, and Atas in the interior, chiefly about Lake Mainit. There are a few Chinese traders along the coast and also some Spaniards, Americans are few.

The Spaniards dispatched an expedition to Surigao in 1609 that eventuated in their control of the province, and the natives where gradually Christianized, but the province suffered severely from raids by the Moros from time to time, until their power was reduced.

AGRICULTURAL AND OTHER INDUSTRIES

Rice, abacá, coconuts, and corn are the most important products of Surigao, while some sugar cane and tobacco are also raised, as shown in the following table.

TABLE XVIII.—*Agricultural statistics for Surigao, 1920*

Crop	Area	Yield	Value
	Hectares		*Pesos*
Rice	16,664	[a] 237,571	3,007,359
Sugar cane (sugar)	475	[b] 741	288,193
Coconut (copra)	5,912	[b] 5,061	1,474,820
Abacá	25,889	[b] 8,369	2,392,234
Corn	5,759	[a] 56,227	425,119
Tobacco	249	[b] 116	66,541
Total	54,948		7,594,266

[a] Hectoliters. [b] Metric tons.

For further development along agricultural lines the country is best adapted to coconuts, abacá, and rice. Though the forests are extensive, no lumbering operations are in progress. Some rattan, almaciga, and tanbarks are collected and exported, but these activities could be greatly enlarged.

Coal, iron, copper, and gold have been found but little is known of the extent of these deposits, and no mining operations of importance are in progress.

TRANSPORTATION AND COMMUNICATIONS

Steamers from Manila make regular calls at Surigao, and smaller craft from Tacloban, Leyte, and Calbayog and Catbalogan, Samar, also call at some of the towns on the east coast of Surigao. A cable from Surigao to Tacloban connects the province with the outside world. A local telephone system connects the principal towns but the roads are poor and communication is largely on the water.

The landing for Surigao is located about 1 kilometer from the town on Bilanbilan Bay. The most protected, good anchorages on the coast are Bitangan Bay, Lamon anchorage, and Catarman anchorage.

Oversized Foldout

ZAMBOANGA

GENERAL DESCRIPTION

Zamboanga Province (Plate XXX) includes most of the peninsula projecting east of Pangil Bay in the north and Illana Bay to the south, on the Island of Mindanao, and Basilan, Olutanga and some 146 smaller islands, and has an area of 6,383 square miles and a population of 146,846 inhabitants. Zamboanga is, therefore, larger than the States of Connecticut and Rhode Island.

Located between 121° 21′ and 123° 23′ east longitude, and between 6° 25′ and 8° 44′ north latitude, Zamboanga is bounded on the east by Misamis Province, Pañgil Bay, and Lanao; on the south by the Celebes Sea; and on the north and west by the Sulu Sea. The coast line, approximately 700 miles long, is indented by several bays of which Sibugay, Dumakilas, and Sindangan are the largest. Caldera Bay, Masinlok, Port Santa Maria, Panabutan, Talaguilung, Sambolauan, Margosatubig, and Port Banga are smaller but well protected bays with excellent anchorage.

Zamboanga peninsula is largely a mountain range, with several peaks rising now and then to 600 or more meters in height. Numerous short streams and rivers wind their way between the mountains to the sea, of which the Dipolog, Dapitan, Lubungon, Piau, Siokon, Sibuku, Vitali, Kumalarang, Kabasalan, Kulasian, Tukuran, Bakalan, and Labangan are the largest and the most important. Many of these rivers could be utilized as a source of power for industrial purposes but all are too small and too shallow to be navigable for any but small river craft, and then only for a few kilometers inland, owing to the rapidly rising formation of the land.

Because of the mountainous character of the mainland, this part of Zamboanga is not well adapted to agricultural pursuits except in small, isolated valleys and pockets here and there along the coast, usually at the mouth of a river. The largest of these valleys are located at Dipolog, Dapitan, Lubungon, and Sindangan. Then, the following rivers flow through smaller but also very fertile valleys:

The Tukuran River, which empties near the Lanao boundary into Illana Bay and is navigable for 6 miles from the coast by small boats; the Labangan River, which empties a few miles east of the Tukuran River, which it exceeds in length and volume of water; the Kumalarang River draining Lake Danao and emptying into Dumankilas Bay; the Kabasalan River, which forms a small delta emptying at the head of Sibugay Bay, navigable for motor boats for about 10 miles; the Bakalan River, navigable for a small launch for 5 miles from the coast; the Dinas River, that forms a marshy delta emptying into the sea in three arms off Pisan Island; the Sibuku River entering the bay of the same name on the west coast of the peninsula; the Siokon River flowing into Siokon Bay; and the Piau or Sindagan River, which empties into Sindagan Bay and is said to be navigable for small motor boats for 10 miles from the mouth of the river. The basin draining into Sindagan Bay includes the largest single grazing area in Zamboanga Province adapted to cattle raising. In the large, fertile Dipolog Valley, the river is navigable by motor craft to Polanko and by smaller boats still further inland. The Dapitan River is navigable by launch to Ilaya.

The land formation of the Island of Basilan, the largest and the most important in the province, some 430 square miles in extent, located at about 20 kilometers to the south of Zamboanga, the provincial capital, differs radically from that on the "mainland." The rise of the mountains here is so gradual that though several attain an elevation ranging from 300 to 1,020 meters, the greater part of the now heavily timbered slopes ultimately will be available for agricultural purposes when the lumber cutting now in progress is finished. Between the mountains lie several plains of unrivaled fertility of which the Lamitan plain, extending on both sides of Gubauan River and emptying into a shallow bay to the northeast; the Balaktasan plain, extending from Latuan to Isabela, centered around Balaktasan River, which really is only an extension of the Lamitan Valley; and the Malusu Valley, in the southwest, about the river of the same name, are the most extensive. While the mountains are forested, the vegetation on the plains and on the lower slopes consists of secondary jungle growth and cogon. The soil varies from rich, alluvial deposits devoid of, or containing more or less laterite to volcanic ash; as a rule it is friable. Generally free of stones and boulders, again, in other localities these are present in such numbers as to seriously impede ordinary cultivation and render the employment of motor drawn implements impracticable. According to the surveys of the Bureau of Forestry, Zamboanga has 1,320,233 hectares commercial forest, 78,924 hectares cogonales. Mangrove swamps and noncommercial forest cover 102,726 hectares, 31,906 hectares or 1.9 per cent of the land is under cultivation, 119,408 hectares are still unexplored.

CLIMATE

The rainfall of Zamboanga is quite varied, which in part may be seen from the following table adapted from the records published by the Philippine Weather Bureau.

Zamboanga has the lowest mean annual precipitation recorded in the Philippines. This condition applies, however, to a very circumscribed area adjacent to the city itself, and the rainfall is very much greater within a few miles of Zamboanga proper. In Dapitan the rainfall is more than double that of Zambanga, in Isabela nearly so. Again, the rainfall table of the latter place, while probably representative of the coast line and valleys in Basilan, does not indicate the true figures of the precipitation in the interior, where the rainfall on at least some mountain slopes at even less than 150 meters' altitude is twice that in Isabela, with soil greater precipitation at the higher elevations. In the Margosatubig district the rainfall, which is very equally distributed throughout the year, is estimated at not less than 3,000 millimeters annually and it is probably considerably greater.

TABLE XIX.—*Mean monthly and annual rainfall in Zamboanga Province*

Month	Municipalities		
	Zamboanga	Isabela Basilan	Dapitan
	mm.	*mm.*	*mm.*
January	37.2	54.4	118.4
February	62.0	89.2	123.3
March	21.0	58.2	55.7
April	38.2	89.2	110.2
May	72.0	108.0	70.9
June	88.8	210.6	117.7
July	99.0	208.4	151.6
August	95.0	205.8	89.3
September	106.3	201.6	141.6
October	116.1	261.7	246.0
November	106.5	168.4	369.7
December	84.3	138.6	277.4
Total	926.4	1,794.1	1,871.8
Rainy days	94.8	153.1	140.8

TABLE XX.—*Annual rainfall at the Basilan plantation*

Month	1912	1913	1914	1915	1916
	mm.	*mm.*	*mm.*	*mm.*	*mm.*
January	127.0	76.7	36.8	68.5	487.6
February	48.2	27.9	19.0	12.7	125.7
March	----------	196.8	29.2	50.8	121.9
April	57.1	212.0	180.3	60.3	68.5
May	57.3	194.3	218.4	333.4	226.5
June	300.9	440.6	312.4	410.7	306.0
July	359.4	265.4	254.0	584.7	242.5
August	163.8	248.9	68.5	259.0	429.2
September	111.7	289.5	264.1	286.2	247.6
October	436.8	429.2	144.7	326.3	721.8
November	101.6	162.5	128.2	247.6	222.2
December	49.2	163.8	128.2	584.2	391.6
Total	1,843.0	2,707.6	1,783.8	3,424.4	3,591.1

The observations in Table XX were made about 2 kilometers inland from Isabela, at an elevation approximately 50 meters above sea level.

POPULATION

As stated already on a previous page, the population is over 146,000 souls. A few of these are Americans and Europeans, mostly living in Zamboanga and representing commercial houses, or in charge of plantations. The Filipinos live principally in the Dipolog and Dapitan district and in and around Zamboanga, and are occupied by agricultural pursuits. The Moros inhabit the coast and the adjacent islands from Lanao on the south coast to Sindangan in the north, and gain their livelihood by fishing and farming, chiefly the former occupation. The Subanos inhabit the interior of the Zamboanga peninsula, and the Yakans inhabit Basilan. These two tribes are both very primitive and they support themselves by hunting and farming.

For plantation labor the Subanos are considered the best workers. Yakans are less efficient. The Filipinos and the Moros are engaged in their own pursuits and with few exceptions are not available for hire. Here, as in all other provinces of the Archipelago, the local trade is largely in the hands of Chinese. The Japanese settlers are few.

HISTORICAL REVIEW

To the American having in mind the rapid development of his own country, the old history of present day Zamboanga seems almost inconceivable.

Dapitan passed under the yoke of Spain in 1565. Cinnamon, probably the Kami, *Cinnamomum mindanaense,* is recorded to have been exported in large quantities as early as 1598 from Caldera, which for some time previous had been a trading post. The first Jesuit mission was established in Dapitan in 1631. The earliest Spanish settlement in Zamboanga was made in 1635. Basilan was ceded to the Spanish crown in 1726, and the fort at Isabela was constructed in 1842. In 1831 the first customhouse was established in Zamboanga. The city was occupied by the Americans in 1899 and Zamboanga was made a province and civil government established in 1914.

AGRICULTURAL INDUSTRIES

Coconuts, rice, abacá, corn, rubber, and coffee are the principal crops of the province, in the order named, and were, in 1920, planted in the following areas according to statistics compiled by this Bureau:

TABLE XXI.—*Agricultural statistics for Zamboanga, 1920*

Crop	Area	Yield	Value
	Hectares		*Pesos*
Rice	4,967	[a] 53,284	398,267
Sugar cane (sugar)	177	[b] 514	161,688
Coconuts (copra)	16,784	[b] 23,022	7,611,412
Abacá	5,284	[b] 2,048	458,641
Corn	4,917	[a] 40,527	518,770
Tobacco	49	[b] 5	2,700
Total	32,178		9,151,478

[a] Hectoliters.

[b] Metric tons.

Most of the coconuts are produced in the settled country adjacent to Zamboanga, from Patalon in the north to Manikahan on the east coast. Smaller areas are planted in Isabela, Basilan, and in the Dipolog and Dapitan valleys, with scattered, small plantations here and there along the coast. In rice production Dipolog leads, which also is the principal abacá district. Zamboanga leads all provinces in the Philippines in rubber production. Considerable quantities of coffee is also being grown. The production of sugar, cacao, maguey, and tobacco is insignificant.

The principal vegetable and miscellaneous food crops grown in Zamboanga do not differ very greatly from those in other provinces in the Philippines except that cassava is very extensively grown by the Moros. The other more important vegetables include camotes, squash, pumpkins, upo, tomatoes, eggplants, sitao, peanuts, gabi, ubi, and cucumbers.

At San Ramon Farm a very great variety of temperate zone vegetables are grown very successfully. The production of Bermuda onions of excellent quality is especially worthy of note, considering that this item forms such an exceptionally high figure in the vegetable imports of the Archipelago, in 1918 amounting to 4,702,912 kilos valued at ₱331,883.

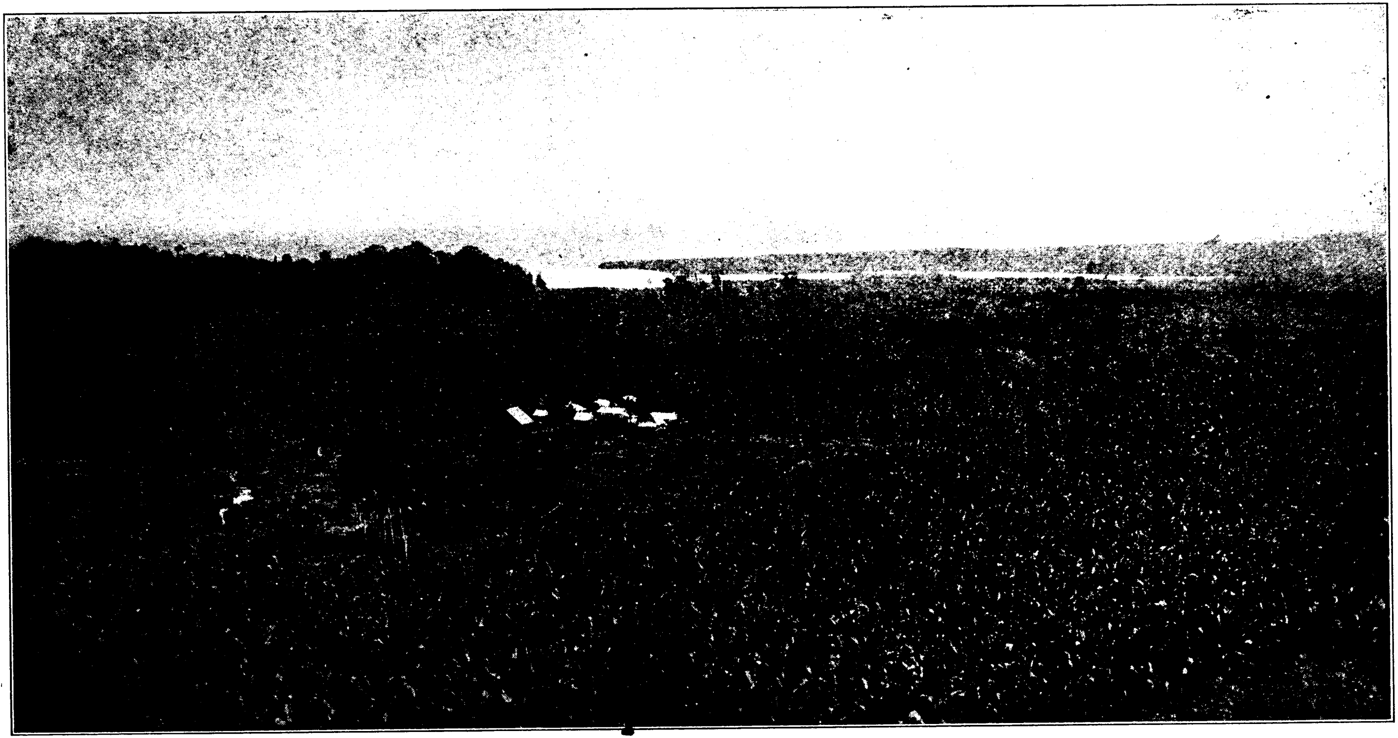
The Bauno, Huani, Marang, and Rambutan are especially worthy of note as being found wild or naturalized in great numbers in Basilan and being of remarkably good quality, more particularly the Marang and Bauno. Mangosteens were planted in Dapitan many years ago, and there are several trees 10 to 12 meters high, bearing abundant annual crops.

PLANTATIONS

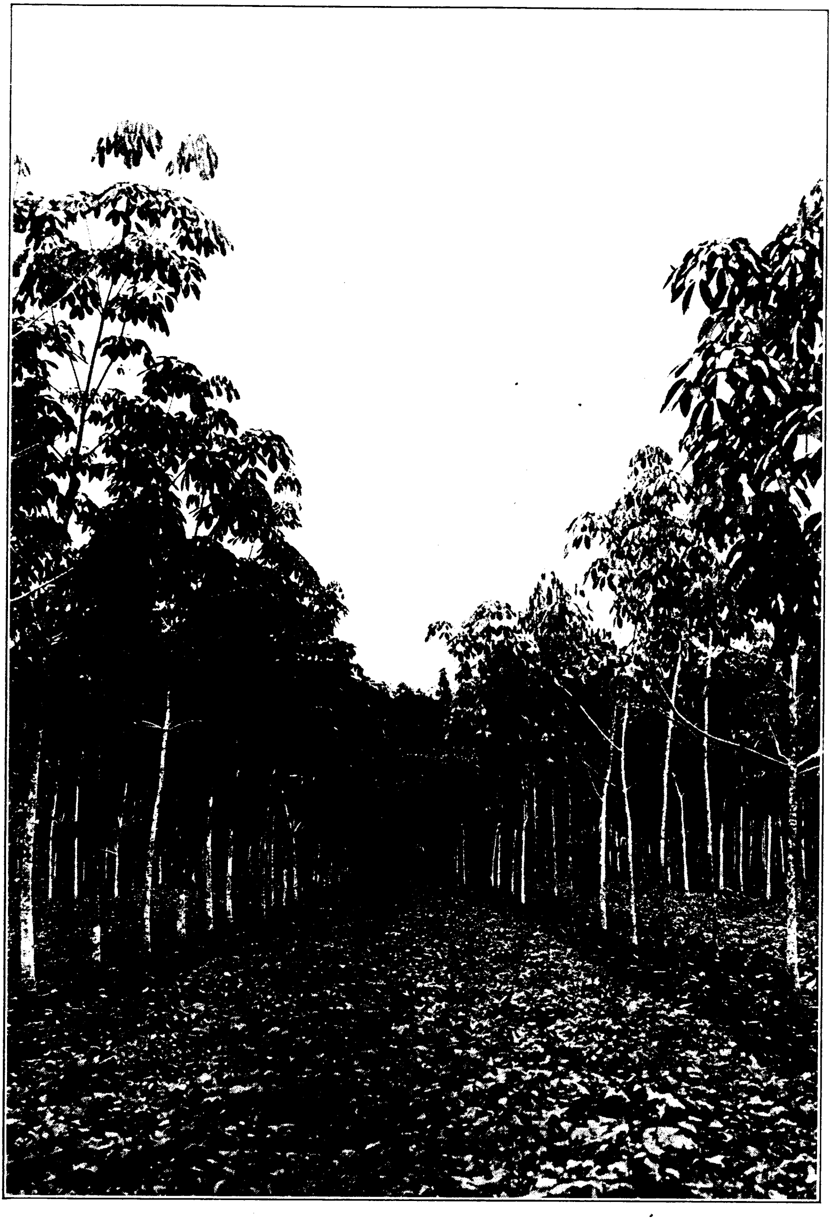
Aside from several more modest ventures, nine corporations capitalized at from ₱50,000 to ₱500,000, are engaged in developing plantations of coconuts, abacá, coffee, and rubber from 230 to 1,024 hectares in extent. The most notable of these is the Basilan Plantation Co. with an area of 1,024 hectares, which is the pioneer rubber plantation in the Philippines and now has about 81,000 Para rubber trees growing, and a large area planted to coconuts. (Plate XXXI.) Some 600 hectares are under cultivation on this plantation and the clearing of the remaining jungle has been delayed only because of insufficient labor. It is the success attained by this plantation that has induced other capitalists to later rubber ventures in Basilan and Mindanao. A modern rubber dyring house 12 by 36 meters two stores high has been erected by this company within the last year.

The 17,000 Para rubber trees on the Balaktasan Estate, Basilan, acquired by Japanese in 1918, continue to make satisfactory progress. (Plate XXXII.)

The Patalon plantation (Plate XXXIII), a few kilometers to the north of San Ramon, devoted to coconuts and coffee, is signally successful and is an eminent example of what can be accomplished in Philippine plantation ventures under good management. As coffee plantations go in other countries, the one at Patalon is, of course, a very modest affair, including only some 36,000 trees. Nevertheless, it enjoys the distinction of being at present the largest rationally cared for coffee plantation in the Philippines, and the first to definitely demonstrate that Robusta coffee can successfully be grown in these Islands. The soil being of a very patchy character, it has shown how wonderfully productive Robusta coffee is when the soil conditions are what they should be for this coffee, but failure in other fields have strikingly demonstrated how unprofitable Robusta is when planted under uncongenial conditions. Robusta and Liberian are the two varieties principally planted, while several of the new, rust-resistant kinds are also being tried; the Excelsa and Quillou being especially promising. The Liberian coffee



Birdseye view of the Basilan rubber and coconut plantation, the oldest rubber plantation in the Philippines



Para rubber in the fourth year, Balaktasan, Basilan

Coffee and coconut plantation, Patalon, Zamboanga

produced is disposed of at ₱94 and Robusta ₱74 per 100 kilos in Zamboanga.

The American Plantation Company has made more rapid progress in development work than any other corporation during the past year. The concession of this company includes some 1,000 hectares of excellent land located on the Balaktasan River, a short distance from Isabela, Basilan. More than 500 hectares have already been cleared, of which a large area is planted to Para rubber, and at the present rate of progress the entire tract will probably be occupied by rubber at the end of 1921. The American Plantation Company is the first concern to employ tractors in developing a plantation in this part of the Philippines.

NATURAL RESOURCES AND PRODUCTS OTHER THAN AGRICULTURAL

The Islands of Basilan presents very great potential opportunities for agricultural development but the immediately available resources of the province are the large forests, which are exceeded in area and value only by those of Davao and Cotabato. The timber trees range from the soft lightwoods, such as lauan, *Shorea*, spp., *Pentacme contorta, Parashorea plicata* and *Anisoptera thurifera;* lumbayao, *Tarrietia javanica* and calantas, *Toona calantas;* to heavy hardwoods, such as yacal, *Hopea* spp. mancono, *Xanthostemon verdugonianus;* ipil, *Intsia bijuga;* molave, *Vitex* spp.; pagatpat, *Sonneratia caseolaris;* camagon, *Diospyros discolor;* dinglas, *Eucalyptus naudiniana;* narra, *Pterocarpus indicus;* and tindalo, *Cassia javanica* and *Pahudia rhomboida,* of which the hardwoods are used for posts, piles, ties, and cabinet woods, while the lightwoods are employed for light construction and interior finish.

Lumber mills are operated by the following corporations: The Basilan Lumber Co., with mills at Isabela and Malusu; the Olutanga Sawmill Co., with mill at Olutanga; the Mindanao Sawmill Co., with mills at Naga-naga and Margosatubig; and the Port Banga Sawmill Co., with mill at Bangaan.

Other forest products which are collected in greater or less quantities for export are almaciga, gutta-percha, cascalote (tan bark), rattans and beeswax, but the production of all could be greatly increased.

Coal of good quality has been known for a number of years to exist in the peninsula between Payao and Malangas, and the National Development Company, with headquarters at Malangas, has been occupied for nearly two years with surveys and other preliminary work incident to mining the coal deposits which are believed to be very extensive.

The marine products of Zamboanga include pearls and shells, the exports of which totaled ₱81,943 in 1918. Small amounts of bêche de mer, shark fins, coral and sponges are also produced. Fish of excellent quality is plentiful in the market at all times of the year. Salt is produced in Talontalon near Zamboanga for local consumption.

ZAMBOANGA, THE CAPITAL

Zamboanga is the capital of the province which it has given its name.

With its balmy climate, clear, limpid skies, brilliantly blue water, the wonderfully colorful sunsets over the vast expanse over the sea, the opulent vegetation, its tall, waving coconut palms, shady streets, and effects in decorative landscape gardening not forgetting turbaned Moros gay in their habiliments of bright colored cloth, the city of Zamboanga possesses a charm quite foreign to the seaports to the north in the Philippine Archipelago. Violent storms are rare. So different from the islands in the north is, indeed, the general atmosphere of Zamboanga that here one might imagine oneself in a foreign country, more akin to Java and all that name implies.

TRANSPORTATION AND COMMUNICATIONS

For connection with the outside world Zamboanga is served by several steamship lines. The *Nippon Yusen Kaisha* steamers plying between Yokohama, Hongkong, Manila, and Sydney make Zamboanga a port of call. All inter-island steamers from Manila to Jolo, Cotabato and Davao, such as the *Islas Filipinas, Yazoo, Neil MacLeod, Albay, Fernandez Hermanos, D. Ildefonso, Mindanao, Raritan* and others call at Zamboanga on their way to and from Manila via Cebu and Dumaguete. The *Tablas* provides monthly communication with the north coast of Mindanao as far as Butuan, touching at all the important points, such as Dapitan, Dipolog, Misamis, Kolambugan, Iligan and Cagayan, and at the less known points whenever there is sufficient cargo to warrant a stop; on the south coast calling at Cotabato, Lebak, and the Davao ports as far as Mati, and making occasional trips to Jolo, Cagayan de Sulu and Siasi, which as a matter of fact, is also done by the *Mindanao*. There are also steamers plying monthly between Zamboanga, Borneo and Singapore. Direct connection with Iloilo and other insular ports not mentioned is erratic and irregular and as a rule travel there from Zamboanga must be made via Manila. The U. S. Army transports arrive monthly from Manila. Large and

Oversized
Foldout

small launches handle the inter-provincial trade, while many sailing vessels touch there from domestic and foreign ports.

The strategic location of the point of the Zamboanga Peninsula of Mindanao, facing Basilan Strait, on the line of travel from Australia to Manila, Hongkong, and Japan (Plate XXXIV)—it is the logical place for a port of call for steamers plying between Singapore and Borneo, the point where all inter-island steamers must pass and meet on their way between Manila and the Davao and Cotabato ports and Jolo, and from the north to the south coasts of Mindanao—is an assurance that here will always be one of the most important seaports in the Philippine Archipelago. And its activities will inevitably expand coincidently with the development of Mindanao, for which island it will remain the central supply depot and port of entry for the machinery, supplies, and foodstuffs that will be required for importation incident to the opening up of this great island, at least until an adequate transportation system shall have been developed in the great agricultural regions, uniting them with more convenient shipping points such as conceivably may be established at Parang, Nasipit, Kolambugan, and Malalag. At present Zamboanga is the port of call on the Basilan Strait. A pretty little town, Zamboanga unfortunately lacks natural advantages for growing into a big seaport. Located at the point of the peninsula, the port area has no protection from storms though fortunately they are rare. The water is shallow, necessitating the construction of long expensive piers in the event of its development into a port of more than ordinary importance. The swift sea current near the shore renders the approach to the docks difficult, if not dangerous. The town site itself is flat and unattractive, being a beach exposed to tidal waves, with a swamp for a background, into which the town is already expanding.

How Zamboanga "happened," so to speak, during the turbulent days when Spain was endeavoring to extend her empire in this part of the world is well-known. But with the pacification of Mindanao the powerful motives which compelled the Spaniards to abandon their early settlements at Caldera Bay and Masinlok and build another at Zamboanga, where they were less exposed to danger from attacks of the Moros, have disappeared. With two natural harbors a short distance away—Caldera Bay and Masinlok anchorage—there seems now to be every reason why a new port should be developed. Of the two harbors Masinlok is the roomier and has the greater natural protection, but the entrance is dangerous because of strong currents and shifting beds; the adjacent land is low, swampy, and unattractive. The natural harbor of Caldera Bay is smaller, but sea currents are absent and do not interfere with navigation in entering the harbor. The rising hills on one side would afford an excellent town site, and the flat land back of the head of the bay could be dredged out for large docks. Where it would be desirable to raise the low area this could easily and cheaply be accomplished by sluicing down earth from the hills near by.

As a matter of fact Caldera Bay because of its natural advantages for many years has served as a "coaling station" in this part of the Philippine Archipelago, and is used as a harbor for steamers during stormy weather. Indeed, the superior advantages of Caldera Bay as a harbor were early recognized by the Spaniards, as far back as 1596, and used as a base of operations during their warfare against the Cotabato Moros. When it is considered, too, that no amount of money will ever make a Caldera Bay out of Zamboanga harbor, it is believed that a careful investigation by competent engineers, navigators, and economists would show that a transfer of the port would be justified as an economically sound move.

In fine, the development of a port at Caldera Bay would be attended by the following advantages over that at Zamboanga:

(1) Easier approach to the port.
(2) Superior anchorage closer to the shore.
(3) Better protection for the shipping during bad weather.
(4) Quicker and cheaper coaling of steamers.
(5) Cheaper harbor and wharf construction.
(6) A greatly superior and more attractive town site with adequate protection against tidal waves.

Zamboanga has direct cable communications with Basilan and Jolo and with Manila via Cebu and Dumaguete. The Zamboanga telephone system extends to San Ramon and Patalon on the one coast and to Manicahan and Buenavista on the other. Dapitan is also connected by a cable with Cebu, and a local telephone system links up the settlements in the northeast corner of the province with each other and with the adjoining part of Misamis Province. There are five wireless stations in the province. One each in Zamboanga, Isabela, Sindangan, Malangas and Margosatubig.

A first class road has been constructed from Zamboanga to San Ramon on one hand and to Manicahan on the other, and a second class road is under construction from Isabela to Lamitan. Transportation between the different municipalities in the province is consequently almost entirely by water on the sea coast.

TRADE

The foreign exports of the port of Zamboanga during 1918 amounted to ₱498,187, while the domestic exports amounted to ₱2,798,723, the bulk of which consisted of copra, lumber, abacá, marine shells and rubber, in the order named. According to the Annual Report of the Bureau of Customs, the foreign imports for the same year amounted to ₱1,354,051. These figures do not, however, represent the total imports and exports of the province. There were 44 entrances and 35 clearances of foreign vessels during the year, while 804 and 827 coastwise vessels entered and cleared, respectively.

SAN RAMON FARM

This institution, located about 15 miles north of Zamboanga, on the coast, was established as the result of an order issued as far back as 1866, by the Spanish government, and as such was taken over by the American government after the occupation of the Islands. As now managed the San Ramon Penal Farm is a model institution of its kind. The convicts perform all the labor on the farm which is managed according to the most advanced methods in tropical agriculture and is now a self-supporting institution, and is also largely self-sustaining relative to food requirements. The land is practically all occupied by coconuts, with small areas devoted to vegetables for home consumption and sale in Zamboanga. At the San Ramon Farm the prisoner is made to support himself while serving his sentence, and while in durance is so occupied that he leaves the institution a far more intelligent and efficient and healthier person than when he entered the farm, and has a far better conception of the management of coconut palms and other general farm work than a majority of the farmers in this part of the world.

PROSPECTIVE AGRICULTURAL INDUSTRIES AND DEVELOPMENT WORK

Richly endowed with forests, Zamboanga for many years will continue as one of the principal sources of lumber in the Philippines and the exports will increase as new mills, for which there is ample room, are erected. Cutch and tanning extracts in large quantities could be exported.

While it is true that, due to the mountainous character of the country, by far the greater part of Zamboanga Province is unadapted to agriculture, in other parts of the province the opportunities for agricultural development are exceptionally good. For the investor with big capital, who wishes to engage in the culture of coconuts, rubber, abacá or coffee, in Basilan there are large areas of excellent public land available for occupation within easier reach of the beaten path of travel than anywhere else in the Philippines.

Possessing deep water close to the shore and being well protected by the nearby Island of Malamaui, Isabela, the capital of Basilan, has excellent advantages for development into a good harbor and shipping point, a fact long ago appreciated by the Spaniards who, in connection with the strongly constructed fort, since fallen into ruins, operated at Isabela a naval station and shipyard before the American occupation. At a more advanced stage in the development of the fertile Island of Basilan, Isabela will unquestionably grow into a lively trade center for Basilan and adjacent islands to the south and southwest, and her rubber, coffee, abacá and coconut oil be loaded direct on the ocean-going steamers for export to America and Europe.

Probably too wet for coffee, the Margosatubig district is worthy of investigation by rubber, abacá, and coconut planters. The large valley in Sindangan offers opportunities to the cattle rancher and possibly to the coconut planter.

Though the opportunities for exploitation by big capital are limited to Basilan, the Margosatubig district and Sindangan, the opportunities for settlement and investment by the small farmer desirous to take up a homestead or the small planter who contemplates the development of a plantation 50 to 200 hectares in extent are almost unlimited.

While coconuts, coffee and abacá are recommended for planting in the more remote regions, the city of Zamboanga would absorb very considerable quantities of vegetables, fruits and poultry products of all kinds which at present are very scarce and command a high price; and vegetable and poultry farms should prove the source of a very comfortable income to the intelligent farmer in this locality. It is a remarkable fact that though pineapples, bananas, papayas, jacks, lanzones, citrus, and many other fruits grow with the greatest luxuriance, that they are of good quality and the supply of these fruits is very limited and the prices are high, yet not one has taken advantage of these conditions to supply the demand. Citrus fruits of good quality are produced, yet oranges and lemons are imported from far away California and Australia.

The shipping facilities are not sufficiently good for the production of mangosteens for export from Dapitan and Dipolog, but Basilan has a soil, climate and location that would insure the success of a big mangosteen project with a view to supplying Zamboanga, Cebu, Iloilo, Tacloban and even Manila with mangosteens, which cities now receive fitful shipments of this fruit from Saigon and Singapore, and while it is true that the mangosteens can be grown on the entire north and south coast of Mindanao from Zamboanga to Surigao and to Davao respectively in Laguna, in the Bicol provinces and in the moist Visayas, the Basilan mangosteen planter would in all probability have the entire Philippine mangosteen market to himself on the principle that it is always so much easier to buy than to grow mangosteens.

THE SULU ARCHIPELAGO

DESCRIPTION

The Sulu Archipelago (Plate XXXV) is a group of islands located between 119° and 122° east longitude and between 4° and 7° north latitude, extending in a southwesterly direction from Basilan to Borneo, bounded by the Sulu Sea on the north and the Celebes Sea on the south and east. The entire length of the Archipelago is approximately 137 miles, and it includes about 130 fairly large islands, most of which are inhabited, and some 170 islets and reefs chiefly of geographical interest. The Sulu Archipelago has an estimated area of 1,030 square miles and a population of 156,212 inhabitants according to the Census of 1919.

As in the other parts of the Philippines, all the larger islands in the Sulu Archipelago are of volcanic origin, and the location of these islands and the topography of the sea bottom suggests that once the Sulu Archipelago may have been the connecting link of a continent extending from Mindanao, the Visayas and Luzon in the northeast, to Borneo in the southwest.

The Sulu Archipelago is usually considered in two large groups, the Jolo group and the Tawitawi group. These two agglomerations are again divided into 13 small groups with principal islands as follows:

(1) The Samales group, lying east of Jolo, including among others the following inhabited islands: Tatalan, Bukutua, Bulan, Tonquil, Balanguingui, Simisa, Bangalao, and Manuñgut.

(2) The Jolo group, including the Islands of Jolo, Kapual, Bitinan, Tulayan, Gujangan, Bankungan, Morongos, Pangasinan, Hegad, Manis, Bubuan, Kabukan, Pantokunan, and Sulade, all of which are inhabited. Jolo is the largest island in the Archipelago; and here Jolo, the provincial capital, is located.

(3) The Pangutaran group, comprising the following inhabited island; Pangutaran, Pandukan, Kulassein, Tubigan, Teomabal, North Ubian, Malikut, Tikul, Usada, and Kunilan.

(4) The south Jolo group, including Patian, Lumbian, Damokan, Tambulian, Dongdong, and Pata, which are inhabited.

Oversized Foldout

(5) The Tapul group, which consists of Tapul, Lugus, Taluk, Paquia, Kabingaan, Tara, Laminusa, Siasi, Lapak, Manubul, and Tapaan, all of which are inhabited.

(6) The Kinapusan group, including the following inhabited islands: Tabawan, Bintoulan, Kinapusan, Loran, and South Ubian.

(7) The Tabuan group, comprising a number of little islands of which one, Tabuan, is inhabited.

(8) The Tawitawi group, including Tawitawi, Tandubas, Secuban, Latuan, Mantabuan, Banaran, Bilatan, Manukmanca, Simunul, Laa, Bongao, Papahag, and Sanga Sanga, inhabited islands.

(9) The Sigboye group, of which the following islands are inhabited: Sigboye, Tambagaan, and Tagao.

(10) The Tataan group, of which only Basun and Tinagta are inhabited.

(11) The Sibutu group, including Sibutu, Omapui, Sinpakot, Tumindao, and Sitanki, inhabited islands.

(12) The Pearl Bank group, of which Cap is the only inhabited island.

(13) Cagayan de Sulu group, of which Cagayan de Sulu, Taganak, and Baguan are inhabited.

The majority of the smaller islands and reefs are coralline and the approach to many of these is very dangerous and difficult because of the shallow water and the narrow, tortuous channels between the reefs. The coral islands are all distinguished by the flat, low formation of the land and comparatively shallow, light sandy soil, whereas those of volcanic origin rise more or less abruptly out of the sea or, if they are of gentle slope, are characterized by mountains rising to a greater or less height.

Among the islands worthy of more than passing mention: Bakungan is a precipitous, densely wooded island about one mile long and half as wide, located about 11 miles east of Jolo. The inhabitants are occupied principally in fishing. The best anchorage is found on the south side of the island.

Bongao is a small, rocky island off Sanga Sanga, with good anchorage. The precipitous mountain of the same name is about 340 meters high and a striking landmark from a great distance. Farming and fishing are the principal occupations of the people. The town has a small dock approachable by a good-sized launch.

The little Island of Buan, located about midway of Tawitawi on the south side is difficult of access and can be approached only by small motor boats and vintas. It is mentioned because of its numerous springs from which water is obtained by the inhabitants of the neighboring islands. The principal occupations of the population are fishing and farming.

Cagayan de Sulu is about 8 miles long and 15 miles wide, and well elevated above the sea, culminating in a mountain 330 meters high. The island has two small, deep lakes near the south coast and many springs with excellent drinking water. The anchorage at the dock is very good. The island is very fertile and considerable copra is produced; cattle and edible bird nests are other export products.

The Island of Jolo extends from east to west in its greatest dimensions. It is about 60 kilometers long and 23 kilometers broad at its greatest width, with a narrow neck in the middle approximately 6 kilometers wide, again widening at both ends of the island. There are several mountains of considerable height, for instance, Tumantangis, 870 meters high; Sinumaan, 730 meters; Dahu, 700 meters; and Bagsak, 680 meters, but the rise of the land is so gradual that the mountain sides are largely available for agricultural purposes. While by far the greater part of the forests were long ago cleared away there are still considerable areas in forest of which teak is the most valuable.

The landscape of Jolo is extremely pleasing, with its general configuration of a seires of mountains and hills of gentle slope rising out of the sea, undulating hills and valleys, mostly cultivated, or overgrown with cogon and other grasses.

One of the outstanding features of the Jolo landscape are the striking bauno trees, *Mangifera caesia,* which dot the landscape everywhere. Especially conspicuous are these during the blossoming season in June and July, when the trees stand out against the solid green of the forest or on the plains like giant lilacs.

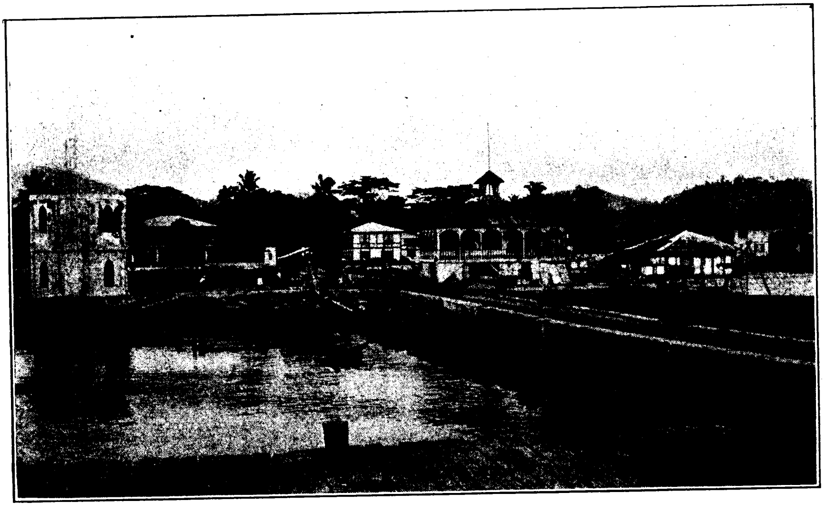
With its many mountains the rainfall of Jolo is also quite abundant and the island is well watered by numerous streams, of which the Palag and Bilaan Rivers are the most important. They have several tributaries.

Port Tulayan, to the east of Jolo on the north coast, is the best harbor on the island and possibly may some day become of importance.

There are a number of small lakes in the craters of extinct volcanoes of which Siit and Crater Lakes are the largest and best known. These are very deep.

Jolo, the provincial capital of the Sulu Archipelago, is located on a wide bay on the north side on the western end of the island. The city is connected with Zamboanga by cable, and has a local telephone system reaching out to several of the more important island villages.

(*a*) Old city gate to Jolo seen from the dock



(*b*) Jolo from the dock

The road system on Jolo is rather incomplete, though one may reach Maibung, Parang, Indanan, and Camp Romandier by auto.

The *Islas Filipinas* calls from Manila and Zamboanga twice monthly and there are monthly steamers between Singapore, Sandakan, Borneo, and Zamboanga with call at Jolo in passing that port each way. Various smaller craft maintain additional communication with Zamboanga and the Sulu Island ports of Siasi, Bongao, Sitanki, and Cagayan de Sulu, where there are small docks.

The foreign and domestic exports of Jolo are shown in the table below. These include most of the exports from the entire Archipelago.

TABLE XXII.—*Domestic and foreign exports from Jolo*

Article	1916	1917	1918
Abacá	606,354	1,031,896	1,301,109
Copra	164,494	728,169	[a] 900,000
Pearl shells	297,475	231,686	196,071
Railroad ties	----------	34,534	105,000
Rice	----------	17,027	103,864
Dried fish	47,871	102,974	85,452
Cloth	54,699	74,411	70,162
Shark fins	23,733	38,010	56,611
Cattle	60,492	56,655	39,388
Trepang	21,150	22,919	29,936
Sugar	4,389	33,484	29,159
Lumbang nuts	----------	----------	12,244
Tortoise shells	2,418	1,148	8,195
Hides	13,669	17,516	7,868
Sea horses	1,582	2,629	4,400
Beeswax	2,904	257	1,337
Almaciga	25,942	8,612	----------
Sponges	13,238	----------	----------
Gutta-percha	3,607	2,012	----------
Gambier	1,634	----------	----------
Tanbark	750	----------	----------
Cinnamon	467	----------	----------
Miscellaneous	----------	----------	----------
Total	1,592,082	2,675,420	3,217,203

[a] Estimate.

Laminusa is a small, low coral island about a mile long largely covered with mangroves. It has a good anchorage but poor water, and is mentioned chiefly because of its pearl and trepang fisheries. Excellent mats are made and exported from Laminusa.

Laparan is a low coral island some seven miles long, in the interior of which is a large lagoon about three miles long. The island has no water and is uninhabited.

Lapak is located across the narrow channel from Siasi and has good anchorage on the north and south coasts. The water, obtained partly from springs and partly from wells, is good. Farming and fishing are the principal occupations of the people. Some copra is exported. Lapak is nearly five miles long and three miles wide, with two mountains at the opposite ends of the island, the one in the north 300 and the one in the south 450 meters high, with a wide plain of good to excellent agricultural land in the middle, practically all uncultivated and overgrown with cogon. Attempts have been made by American planters to grow rubber and cassava on this island but all of them have failed.

Lugus is about four and a half miles long and three miles wide, with a good anchorage on the northern and the west coasts. The land formation is a series of fertile hills rising to one peak about 290 meters in height. There are two small lakes on the island but the drinking water is poor and brackish. The population subsists by farming and fishing, the island being quite well cultivated. Copra is the principal export article.

Mantabuan is a small, flat, quite populous island to the south of Tawitawi, with a good anchorage in the channel between it and Latuan Island. The population is occupied principally in fishing. Some trepang and shells are exported.

The little Island of Manubul, located a little way from Lapak to the southwest, is one of the fishing centers of the Sulu Archipelago, exporting dried fish, shark fins, and trepang. The anchorage is good but there is no drinking water on the island.

Manukmankau is a flat coral island about two miles wide and twice as long lying a little to the south of Simunul. The anchorage is poor. The drinking water is of fair quality and is obtained from a small pond in the center of the island. The people are occupied principally in farming, especially in growing a tobacco which by the Sulus is preferred to all other kinds. Some rattan mats and pottery are also made for export.

Pangutaran is a low, flat coral island some 10 miles long with good anchorage, but having very poor drinking water. Farming is the principal occupation of the inhabitants who export copra and cattle.

Panducan is a low coral island, some 6 miles long and about 2 miles wide, located about 23 miles northwest of Jolo. The people are occupied chiefly in farming. Copra, cattle, and mats form the articles of exports. The anchorage is good on the south coast. The drinking water is very poor.

Pata is an almost circular island of volcanic origin about four and a half miles in diameter with a mountain in the center some 330 meters in height. Pata has a good anchorage and good drinking water from springs. The island is well elevated above the sea, the soil is fertile, and most of the land is under cultivation. Copra and cattle are exported.

Sanga Sanga is an island about 6 miles long located between Tawitawi and Bongao, the population of which are occupied chiefly in farming.

Secubun is a small, low flat coral island with poor and brackish water, the inhabitants of which support themselves by farming and fishing. Dried fish, trepang, pearl and tortoise shells, and copra are exported from Secubun.

Sibutu is a long, narrow island some 16 miles long and perhaps 4 miles at its greatest width, lying southwest of Bongao and only about 25 miles from Borneo. The island is partly of volcanic origin, partly coralline. The people are occupied chiefly in farming and cattle raising though some dried fish and trepang are exported. The cutting of railroad ties is the principal industry.

Simunul is a flat rock island south of Bongao about eight kilometers in diameter. There is no good anchorage off this island but the water is good, being obtained from springs in the center of the island. The exports are principally pearls, shells, and trepang. Wild hogs are quite numerous and there are many wild carabaos descended from escaped domestic animals, most of the island being tilled. Chongos Bay on the southeast coast is a good harbor.

Siasi is an almost circular island of volcanic origin some 10 miles in diameter located 37 miles southwest of Jolo, and is the third most important island in the south Archipelago. There is a gradual and even slopes of the land from the sea to the top of Mount Gorra in the center, attaining a height of 400 meters. The soil is fertile and the land is largely cultivated up to the mountain top or overgrown with cogon. The town of Siasi has a good anchorage and is equipped with a water system. The water, which is excellent, is obtained from springs on the higher slopes of the island. The inhabitants are occupied chiefly by farming and fishing, and copra, abacá, cattle, dried fish, shark fins, trepang, pearls, and shells form the export products.

There is a small Ceara rubber and robusta coffee plantation in Siasi owned by an American corporation. Local industries include mats, pottery, and shell bracelets.

Sitanki is a small island and seaport southwest of Bongao and west of the south end of Sibutu with a good anchorage, but all drinking water is obtained from Sibutu. Some dried fish, trepang, and shark fins are exported.

South Ubian is a small, low and flat coral island about 64 miles southwest of Jolo with a good anchorage, but having very poor brackish water. South Ubian is one of the most thickly populated islands in the Archipelago and is well cultivated. Pearls and shells and trepang are exported from South Ubian.

Tandubas is a small island southeast of the east end of Tawitawi. Agriculturally the island is of no importance but it is quite populous, the inhabitants being occupied with fishing. Pearls and shells and trepang form the chief exports. The anchorage is good on the east coast of the island opposite the town of Ungas Matata. The drinking water is poor and brackish.

Tapul is an island of volcanic origin and with a good anchorage, located about 25 miles southwest of Jolo, the highest peak rising to an elevation of 500 meters. The island is nearly circular and about eight miles across, with springs in the interior that provide good drinking water. The greater part of the island is under cultivation and it is considered as one of the most prosperous in the Archipelago. Excellent mandarins are produced. The exports include coconuts, hemp, citrus fruits, pearls and shells, trepang and dried fish, and some cattle and horses.

Tawitawi is the second largest island in the Sulu Archipelago, being some 35 miles long and 13 miles broad at its greatest width. Unlike Jolo, Tapul, Siasi, and Lugus, which are well adapted for agricultural purposes, the topography of Tawitawi is very broken, rough and mountainous with a range of mountains extending throughout its entire length of which several peaks rise at 300 meters or more, one, the Bihabiha, attaining a height of 580 meters. Several small rivers or, more correctly speaking, streams, find their way from the interior to the sea; of these the Dungun and Malum Rivers are the largest in the Sulu Archipelago. The anchorage on the north coast is good, which is also true on the south coast as far as the town of Balimbing. Drinking water is good and plentiful. Nearly the whole island is covered with dense forest which as yet is largely unexplored. Some railroad ties are being cut and shipped out of the island, but because of its mountainous character Tawitawi will never attain any importance agriculturally.

Tonquil is a narrow, crescent-shaped, flat coral island about 10 miles long located south of Basilan and east of Jolo, with a good anchorage but poor, brackish water. A large part of the island is covered by mangrove. The exports include dried fish, trepang, pearls, shells, and copra.

To the traveler with a love and appreciation of scenic beauty, picturesque surroundings and a study of the primitive, simple life, sufficiently spiced with danger to render the experience more fascinating than an ordinary outing, a cruise through the Sulu Sea is certainly to be recommended.

To the visitor from the temperate zone who travels in the tropics for the first time, the Visayas and other islands to the north of Sulu seem entrancing enough; nor does the eye tire of beholding the wonderful beauty of these islands during successive voyages. But somehow, as one approaches the latitude of Zamboanga and turns southwest towards the Sulu Archipelago, the sky seems bluer and the water more transparently clear, and the atmosphere breathes more of the fabled south seas of which we read in the tales of Stevenson and Marryat. As we pass by a short distance from the shore, there is the white, sandy beach glistening in the brilliant sunlight and the waves gently lapping the shore fringed with the inevitable, stately coconut palms waving indolently in the light breeze over the half decayed timber of a schooner wrecked in bygone days, that set one speculating on the fate of its crew. Part of the beach is occupied by the native village, the nipa houses built over the water and connected with the shore by a gangplank, the typical home of the Samal and the Badjao, or "sea gypsy," as the latter is called. Nor are the people themselves, with their reputation for piracy and smuggling, of less interest than their country, for all that at least the days of the pirate are now past history even in this part of the world. They are accomplished sailors and handle their vintas with great skill, and they are expert fishermen and pearl divers.

If the weather is pleasant, and it is rarely very rough, the cruise is especially enjoyable. The green clad islands rise like emeralds out of the sea on every side in varying sizes and shapes. Mostly wooded or low, of coral line formation, largely uninhabited. Or one lifts itself abruptly above the waves, a rock with scanty soil and scrubby vegetation. Again, the lighter hue of others indicates that the forest has given way to the cogon or the tilled field.

At Siasi the traveler, having passed Tapul and Lugus, on the way from Jolo to the southwest, arrives at a small dock from which extends a road the length of two city blocks which is crossed by another of the same length. Chinese stores wall in the sides of the first block and stretch down one side of the cross road to a ramshackle market built on a pier over the water. Little groups of Samal houses extend out over the water on each side of the town. Further down the channel that divides Siasi from Lapak the visitor sees a good sized village of houses standing on a reef in the water, more than a quarter of a mile from the land. Across on the Island of Lapak he gets a good view of a wide stretch of cogon which appears almost like a great lawn surrounding the attractive, new buildings set in the center of it. These buildings belong to the Lapak agricultural school.

By the time the boat is made fast to the dock the townspeople have gathered to see who has come. There are naked brown children, many with Chinese features; there are Moros who happened to be in town trading; there are dirty Samals, and perhaps a Bajao or two with sunburnt hair falling to the shoulders. The Chinese merchants are out to see what cargoes the boat has brought. A Filipino with bare feet, carrying a shotgun, would, if asked why he was there, reply that he was a policeman and had come to receive the mail. A Constabulary lieutenant has come down from his quarters just beyond the old plaza. The lieutenant will conduct the visitor about the town and show him Siasi. This is not a long task, for there is nothing much to see. But there is plenty to smell. The outside walls of the tiendas are hanging with sharks' fins and tails and in the streets are square mats covered with trepang drying in the sun. These things are the source of the disagreeable odors, especially the shark fins, for there is plenty of flesh attached to the fin that must shrivel and rot away before this is ready for export. (Constabulary monograph on Sulu Province by C. R. Livingstone.)

The visitor to Siasi should remain long enough to make a hike to the top of Mount Gorra, 500 meters high, in the center of the island, whence a better view of the central Sulu Archipelago with its vast number of island and reefs may be had than from any other point.

Next to Jolo, Siasi is the most important trading center in Sulu. The anchorage is good and the channel between Lapak furnishes a reasonably safe harbor. The soil is fertile. Also, a large part of the island is under cultivation. At Tandubas one's attention is drawn to the gigantic coral vases standing in the sea, chiseled out by the waves, the tops crowned with shrubby vegetation.

The bottom of the sea with its innumerable coral forms in all the colors of the rainbow and its many starfish is never ending source of admiration on the shallow reefs and channels. The fish themselves one does not see, of course, in the sea, but "least we forget" no visitor should fail to visit the Jolo fish market with its wonderful variety of fish in every imaginable color and hue.

CLIMATE

The climate of Sulu is mild without violent changes in temperature. The nights are always cool.

The rainfall is plentiful and equally distributed throughout the year. According to the Weather Bureau, whose observations extend from 1902, the mean annual and monthly rainfall is as follows:

	Millimeters
January	89.1
February	122.4
March	85.2
April	118.2
May	160.2
June	203.3
July	172.0
August	170.4
September	184.4
October	222.9
November	193.0
December	144.8
Total	1,865.9

This rainfall corresponds to that of the seacoasts of the Island of Jolo. Further inland on the mountain slopes this precipitation is unquestionably considerably augmented. While the rainfall on Tawitawi probably closely corresponds to that in Jolo, on the remaining islands scattered over the sea, with no mountains of considerable height, it is much less, possibly averaging not more than about 800 or 900 millimeters annually.

POPULATION

The population of Sulu, numbering 156,212 souls, is greater than that of any province in the Department of Mindanao and Sulu, though in area it is smaller.

Tribally the population may be divided into three groups. The Sulus are the most advanced of the native inhabitants, who, before the advent of the Spaniard and American, were the ruling people of Jolo. The Sulus constitute the agricultural population of the Archipelago and from them are largely recruited the labor employed in cutting railroad ties, the one industry in Sulu in which Americans are engaged. They are also engaged in fishing and pearling.

The Samals are, together with the Bajaos, in the majority on the smaller islands and on the coasts of Jolo. Both make their living from the sea, and while the Samals are somewhat more advanced in civilization than the Bajaos, there is really very little difference between the two tribes. The agriculture engaged in by the Samals is of the crudest form, while the Bajaos prefer the sea altogether. The Filipinos in Sulu are very few and of the white race there are still fewer representatives. The Chinese trader in Jolo, Siasi, Bongao, and Sitanki one may not escape any more than in any other trade center in the Philippines. He is the almost indispensable link between the farmer and fisherman and the export houses in the centers of trade in the Philippines.

HISTORICAL REVIEW

The authentic history of Sulu begins about 1380, when the first Arabian missionary is believed to have arrived. He built the first mosque, the ruins of which are still standing in Sulu on the Island of Simunul. Some 10 years later the Raja Baginda arrived from Sumatra. Few people are aware that he brought with him a pair of elephants which were liberated in Jolo and became the parents of a herd of wild elephants which unfortunately were exterminated long ago.

The coming of the Spaniards in 1578 marked the advent of the Caucasian in Sulu, though the suzerainty of Spain was merely nominal for many years. Several expeditions were dispatched by them to Sulu from time to time, some successful as raids, others ending in disaster and defeat inflicted by the Moros. Not until 1851 did the Spaniards permanently occupy Jolo, and even then their authority was never completely established even in Jolo over the entire island and their authority in the outlying islands was merely nominal, and maintained by garrisons at Siasi and Bongao, and in Tataan on the north coast of Tawitawi. In 1899 Jolo was occupied by the Americans. The military régime continued in force until 1914, when civil government was established and the Sulu Archipelago was incorporated into a province in the Department of Mindanao and Sulu.

AGRICULTURAL INDUSTRIES

The agricultural practices in Sulu do not differ materially from those in the other regions in the Philippines, and production per unit area could greatly be increased by more modern methods of culture.

Abacá, the principal product of Sulu, is grown chiefly on the Island of Jolo; the quantity of fiber produced on the other islands is negligible. Soil and climate both are well adapted to abacá over a large area of Jolo Island and the area planted could be increased very considerably, especially in the interior. However, the extension of the abacá plantations may well be left to take care of itself. The more urgent measures are the education of Moro farmer in the need of more thorough preparation of the land before planting, better cultivation and instructions in stripping and grading of the fiber.

Copra constitutes the second largest export article of Sulu but it will unquestionably supersede abacá within the next few years.

Most of the copra is probably produced on Jolo Island though there are few inhabited islands where coconuts have not been planted. On the outlying islands the largest number of coconut trees are found on Tonquil, Pangutaran, Bangalao, and south Ubian. However, the nuts, are, to a great extent, consumed as food in the localities where they are grown. In systematic planting and care of his trees the Moro appears to be behind the Filipino planter in the Visayas and Luzon, in fact, it is doubtful wether there are any, even small plantations, regularly spaced or otherwise properly cared for, and there is a crying need for farm advisers to set the people right in these respects. This is equally true in regard to control measures for beetles and weevils. To no other crop are the numerous coral islands so well adapted as to coconuts and too much could not be done to encourage the extension of coconut plantations on these islands.

Cattle raising is another industry that goes well in hand with coconuts on the larger islands where good water is available. It is especially worthy of attention considering the isolation of the islands and the ease with which diseases can be kept out of this region.

From the export figures quoted on another page, it might be inferred that rice beyond the needs of the population was produced, whereas the rice imports rose to ₱900,000 worth in 1918. Several varieties of upland and lowland rice are grown, upland rice predominating. Most of the rice is grown in Jolo.

In 1918, there were 20 small sugar mills in operation in Jolo but these of course were all of a very primitive type and the quantity of sugar produced was insignificant. Considering how well adapted to coconuts, coffee, rubber, and abacá Jolo Island is, and how well occupied the land in small holdings by the present population, there does not appear to be much room for a sugar industry and it is probable that land now planted to sugar cane could be far more profitably occupied by other crops.

Corn is not of especially great importance as a food crop in Sulu. Cassava is very extensively grown, there being possibly a greater area planted to cassava than to any other single crop. Camotes, ubi, and gabi are also grown to some extent. Other crops of less importance are borona, sesame, and adlay.

The more popular vegetables include patani, squash, patolas, pepinos, tomatoes, watermelons, chili, and kankong. Sago is made from the sago palm.

Jolo is noted for its many fruits, and the climate and soil are very favorable for fruit culture. Mangosteens, baunos, marangs, huanis, durians, and rambutans, unobtainable nearly everywhere else in the Philippines, are abundant in Jolo, in addition to many other fruits, such as the lanzon, bulala, papaya, banana, jack, etc.

The bauno, huani, and marang have hitherto been considered indigenous species but it is a question if this is not a mere assumption and if all these species were not in reality introductions made by the Sulus many years ago. In any event there is a legend among the Joloanos that once a Radja, Ahmat Ansang, sailed to the country of the Malays and brought back seeds of the "Wannih, Mampalam, Baonoh and Marrang." Another time a certain Bandikal Alam sailed to Brunei, Borneo, and brought back the "Doyan, Tomusan and Mangis." However this may be, certain it is that these trees do not grow in any part of the Philippines beyond where Moro influence has exerted itself, the Tomusan, *Nephelium mutabile,* excepted. It is true that the marang was described from Mindoro, but this island was a frequent rendezvous of the Moro in the early history of the Philippines and the introduction of the marang into this island might well have been made from fruits brought along as provisions by the Moro pirates.

The mango produced in Jolo, Zamboanga, Cotabato, Lanao and Davao is very different from those found in the islands further north and here at least there can be no question but that the original introduction was from an altogether different source than that whence came the carabao, pico and pahutan mango of Luzon and the Visayas. It calls to mind the interior mangoes one sees in the markets of Singapore.

The huani is to all practical purposes a large, green mango with long, coarse fibers and a strong flavor of turpentine, and while ordinarily one would not care for this fruit, those who live in Jolo once having acquired a taste for the huani become very fond of it and some even profess to prefer it to the carabao mangoes of Cavite. There is a yellow-fruited form of huani in Jolo called "sangay."

The mangosteen is a fruit the taste of which no one needs to acquire; it is a favorite from the first bite. The Jolo mangosteen is rather larger than those of Singapore and Saigon, and has a thicker rind. The flesh is more acid and has more character than the milder flavored fruit of the Malay peninsula and Java. The seeds are larger. In Jolo an unexcelled preserve is made by boiling the flesh and seeds of the mangosteen in brown sugar, the seeds adding greatly to the excellence of the preserve by their nutty flavor.

The bauno is one of the most common fruits in Jolo and while its odor is almost offensive and the flesh quite fibrous, a liking for this fruit is very readily acquired and usually one becomes very fond of it after a few trials.

The marang at first offends by its too overpowering aroma, but one needs but eat one or two of these richly flavored, sweet fruits to like them. To be at its best the marang should be either under or over ripe as in either even it is of but indifferent eating quality.

The lanzons are one of the common fruits in Jolo and there is one variety called viradali that is eggshaped and much larger than the lanzons ordinarily grown elsewhere in the Philippines.

Durians are abundant and occur in a number of forms, some markedly less malodorous than the ordinary durian.

On the Island of Tapul excellent mandarins are grown and shipped to Jolo. They ripen in June. In Parangan, on the Island of Samamput, mandarin trees of unusual vigor and size have been noted which were said to yield fruit of excellent quality. The limes in Jolo are very juicy and of excellent quality, and good pomelos are likewise reported to be grown. Moreover, the citrus fruits in Jolo are all, so far as observed, entirely free from serious diseases and insect pests such as occur in so many other parts of the Philippine Islands.

Rambutans are quite abundant but are not equal to the best kinds in Java and Singapore. Various other unidentified species of *Nephelium* and *Euphoria* have also been noted.

One of the more interesting finds during a visit to Sulu in 1918 was the Kinubo, *Rubus moluccanus* L., growing at sea level in Tataan, Tawitawi, while several fine specimens of *Mimusops kauki* L. were found growing in Tandubas, in all probability introduced, since this species has never been reported elsewhere in the Philippines.

FOREST AND FOREST PRODUCTS

At present there is only one sawmill in operation in Sulu; it is located in Jolo.

Properly developed the forests products of Sulu should become a very important source of revenue. Public commercial forests are located on Tawitawi, Sibutu, Sanga Sanga, Simunul, Manukmankau, Lintian, Tandubatu, Basbas, Tata, Ampoy, and Tabulunga. These forests contain much the same timbers as the forests in other parts of the islands, both hard and soft wood, such as: Ipil, *Intsia bijuga, Pahudia rhomboida* and *Adenanthera intermedia;* Yakal, *Hopea* spp., *Isoptera borneensis,* and *Shorea balangeran;* Calantas, *Toona calantas* and *Azadirachta integrifoliola;* Lumbayao, *Tarrietia javanica;* Guijo, *Shorea guiso;*

Narra, *Pterocarpus indicus;* and Molave, *Vitex parviflora* and *V. pubescens.*

The only commercial teak forest in the Philippines is located in Jolo, being some 2,500 hectares in area. This is now being logged by the province on a small scale. The most important forest product is railroad ties. Almaciga formerly was collected in considerable quantities but production dropped off to a negligible quantity during the past year. Gutta-percha and gambier have never been collected in appreciable quantities. Some tanbark is obtained and this is an industry that could be increased very considerably. Some lumbang nuts are collected and exported. The Archipelago produces a small quantity of cinnamon. These minor products will never attain much importance, but lumbering, the cutting of railway ties and the collection of tanbark are capable of development into industries of considerable magnitude.

MINING

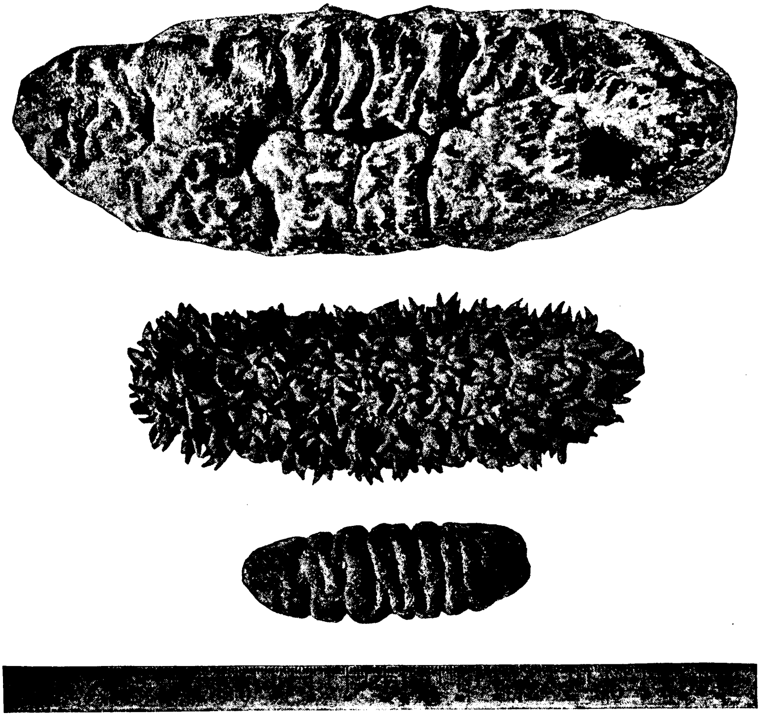
There are no mining operations in progress anywhere, though manganese has been discovered on various islands and gold has been found in Jolo. Oil has been reported from Siasi but no attempt has been made to make borings. It is quite possible that the manganase deposits are large enough to be worth investigating considering that, according to analyses made by the Bureau of Science, the ore contains 62 per cent pure manganese.

MARINE INDUSTRIES

Pearls, pearl shells, tortoise shells, fresh and dried fish, trepang, and shark fins constitute the marine products of Sulu. Of these the fresh fish is the most important, and dried fish is one of the major exports. The fishing grounds are very rich in fish; so rich indeed, that the possibilities of establishing canneries are worth looking into. The fish drying industry has had a remarkable growth. It is, in fact, a new industry, for in 1915 the dried fish exported were valued at but ₱6,094, and it is capable of still further expansion.

The shark fin industry has been of steady growth, but no effort has been made to make oil from the shark livers and guano from the shark themselves. Diving and fishing for pearls and shells is one of the most important industries in the Sulu Archipelago which produces most of the shells and pearls for export from the Philippines. Moros as well as Japanese and Chinese are engaged in this work.

There are many sponge beds in the Sulu Archipelago and several attempts have been made to engage in sponge fishing,



Trepang or Bêche de Mer, one of the marine products of Jolo

which, however, has been abandoned within the last three years. The sponges are reputed to be of good quality. Failure to cure them properly is said to have caused their arrival in the United States in bad order.

Trepang fishing could undoubtedly be engaged in on a far greater scale than at present, which is probably also true of tortoise catching. It is of interest to know that young tortoises are frequently caught and kept in captivity for several years before they are killed. One of the curious sea products of Sulu is the so-called "sea horse," a small animal with head and neck like a miniature horse, which is dried and exported to China because of its supposed medical value.

PROSPECTIVE INDUSTRIES

With few exceptions the development of the industries of the Sulu Archipelago would appear to lie in the hands of the present inhabitants, and opportunities for investment by big capital are not many. There is unquestionably much timber, especially in Tawitawi, but the broken topography of that island would probably make transportation of logs from the interior to the sea more difficult and expensive than in other parts of the Philippines. Railroad ties can be brought out more readily, and this industry may be expected to expand during the next few years. Considerable teak may be expected in the market from the Government reservation but owing to the small area of this forest no very great output can be anticipated for more than a short period. Whether the pearl beds are so extensive that a larger pearling fleet could find profitable work is doubtful. On the other hand it would appear that a well organized sponging outfit, prepared to properly care for the harvested material and place it on the market would be profitable. The value of the pearl and sponge fisheries might be greatly enhanced by the judicious planting of new beds.

As the shark fin industry grows there would appear to be room for a small guano factory to take care of the shark meat and to prepare the oil from the livers that is practically a total loss at present. It is not generally known that shark liver oil is very similar to, and can be used for all the purposes for which cod-liver oil serves.

Broadly speaking, the great agricultural export crops of Sulu will always be copra or coconut oil and abacá. The plantations will be small and probably always remain in the hands of the Moros. There is not sufficient public land available at any one point to induce the American and European with his heavy overhead expenses to engage in coconut growing in this part of the world, considering how much more favorable for plantation ventures all conditions are in Mindanao and Basilan. The same is, of course, true of Para rubber. Coffee is well adapted to native culture and on Jolo there are numerous streams that could be utilized in preparing the coffee, so that there is no reason why, with the adoption of a more diversified system of farming by the Moros, coffee should not become a crop of some importance. In some sections there is excellent tobacco land.

Much land within a radius of eight kilometers of Jolo that is too shallow for other crops could to advantage be planted to pineapples, and cannery in Jolo would be at the same time within easy reach of the plantation and of the wharf, and it might in part be employed for canning fish.

In fine, a region of unsurpassed scenic beauty and romantic interest, inhabited by a virile race of picturesque, interesting people, the Sulu Archipelago, with an older authentic history than any other part of the Philippines, is of unusual interest to the traveler and tourist. Already quite densely populated, Sulu offers but little inducement to the investment of big capital, especially along agricultural lines, and apparently is destined to be developed chiefly by her sturdy native inhabitants.

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THE GOVERNMENT OF THE PHILIPPINE ISLANDS
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
BUREAU OF AGRICULTURE
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THE RUBBER INDUSTRY IN THE MIDDLE EAST

By FRANCISCO G. GALANG
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THE RUBBER INDUSTRY IN THE MIDDLE EAST[1]

By FRANCISCO G. GALANG
Horticulturist

The investigation trip made by the writer to study the rubber industry in the Middle East covered the period from July 23, 1926, to December 12, 1926. It was not exhaustive because of the limited funds at the disposal of the author. The Malaya Peninsula (including Singapore), Sumatra, Java, Ceylon, Lower Burma, Siam and Indo-China were visited.

HISTORY

It appears that all the rubber plantations in the Middle East were started from the seeds brought from Brazil during the early days by one Mr. H. A. Wickham. In detail, the development of the rubber industry in each country is as follows:

The first Para rubber plants in Ceylon were received from the Royal Botanic Garden, Kew, England, in 1876, and set out in Henaratgoda Botanical Garden, 17 miles from Colombo, in 1877. From this planting a few trees remain. The oldest trees there, then, are now 49 years old and the seeds of the first Para rubber plantations in Ceylon were procured from these trees. However, the first planting was mainly Ceara rubber but because of the low yield and difficulty of tapping this variety was abandoned; tea was more profitable. When tea dropped in price, about 25 or 26 years ago, especially in the Kalutara and Kelani Valley districts, people began to plant rubber as an intercrop. The great boom in the rubber industry in Ceylon began only in 1908. Dr. Trimen advocated the planting of rubber as early as 1890–1900 in Ceylon and reported a yield of latex of 1¾ pounds per tree at Henaratgoda. This was increased to 3½ pounds in 1894. The Forest Department planted several thousand acres in 1891 and this was a very profitable move.

About fifty of the original plants in Ceylon were destined for the Singapore Botanic Garden, but all perished in transit. At the same time a few plants were also forwarded to Sir Hugh

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[1] Submitted January 31, 1927.

Low at Perak. These lived and produced fruits in his garden. Another shipment from Ceylon to Singapore Botanic Garden was made in 1877 and trees produced from these were cut recently for a University site. It was from these plants that seeds of the first plantations in Malaya, Java, Sumatra, and Borneo were taken.

The first Para rubber plants in Java were introduced from Kew Garden in 1876 but the planting of these plants was a failure. In 1882 another consignment was received from Perak, Federated Malay States, and from these the present plantations were largely derived. However, not until the year 1907 did the Dutch planters begin to realize the possibilities of rubber, and no extensive planting was undertaken until three years had elapsed. The other rubber producing plants (Ficus) have been abandoned because of their low production—1: 15 in favor of Para rubber—and also because of the difficulty in tapping and extra labor in collecting and curing the rubber, which resulted in much loss of time and the necessity of more careful supervision.

In Java the United Lankat Plantation was the first private rubber enterprise—in 1889—and by 1909, there were 26 concerns owning rubber properties in the Dutch East Indies and since then the number has increased. The number of rubber trees in the Netherlands East Indies exceeds those in Ceylon and equals those in the Federated Malay States. The Government was one of the pioneers in the rubber industry in Java and now it owns and operates successfully 15 rubber estates.

The rubber industry of Siam is said to be 15 years old but received no marked impetus until a couple of years ago, when the increase in demand and rising prices started.

The Lower Burma as well as the Indo-China rubber industry is of recent development, although in one of the estates in Burma some of the oldest rubber trees in the East are to be found. In Lower Burma rubber grows as well as in Malaya, and the farther south you go the better the growth of rubber, it is said.

CLIMATE

The rainfall in the Malayan Peninsula is generally well distributed. The climate is tropical and humid. The temperature averages about 82 degrees and the rainfall 80 inches throughout the year. At the Harvard Estate, Kedah, the rainfall was for:

	Inches
1921	133.99
1922	117.15
1923	91.12
1924	101.78
1925	92.17

The average rainfall of the rubber districts in the Federated Malay States is given below:

	Inches
Perak	115.80
Selangor	89.64
Negri Sembilan	81.69
Pahang	100.13

In Sumatra the rainfall is well distributed and falls usually in the afternoon and at night. It is hot during the day. The table below gives the rainfall of the various rubber districts in Sumatra.

Month	Kisaran,[1] west coast (27 years)		Padang, west coast (39 years)		Sibolga Tapanoeli (39 years)	
	Inches	*Days*	*Inches*	*Days*	*Inches*	*Days*
January	5.3	9.3	13.7	16.2	14.3	17.6
February	3.3	6.8	10.0	12.6	12.4	14.5
March	3.6	7.3	11.9	15.3	16.9	18.3
April	5.2	9.2	14.4	17.0	17.4	19.1
May	6.4	10.8	12.5	14.1	13.5	15.7
June	4.9	8.9	13.1	11.4	10.6	12.3
July	5.1	8.7	11.4	12.1	11.5	13.6
August	7.5	12.1	14.4	14.8	12.5	15.9
September	8.2	12.6	16.3	16.3	13.8	16.9
October	11.3	14.5	20.3	19.7	19.3	20.8
November	8.1	13.1	20.3	21.0	19.6	21.1
December	7.8	11.3	19.6	19.9	16.8	20.4
Total	76.7	124.6	177.9	190.4	178.6	206.2

Month	Djambi (39 years)		Palembang (39 years)		Telok Betong Lampugi (39 years)		Dolok Merangir (18 years)	
	Inches	*Days*	*Inches*	*Days*	*Inches*	*Days*	*Inches*	*Days*
January	9.1	17.9	11.7	19.5	11.0	18.6	8.4	9.6
February	8.5	14.2	10.1	16.5	10.9	17.0	6.2	7.5
March	10.8	17.7	12.4	18.3	9.6	16.7	9.1	10.3
April	10.2	17.2	11.3	16.4	7.1	13.9	9.8	11.1
May	7.5	14.1	7.7	12.9	5.2	11.6	10.6	12.5
June	5.4	10.9	4.8	9.8	4.4	9.9	8.6	10.5
July	4.4	9.5	4.1	7.9	4.2	9.5	7.4	9.0
August	5.9	11.5	4.7	9.2	5.2	10.2	11.4	12.7
September	7.2	12.1	4.8	8.9	5.2	9.3	13.9	13.6
October	9.2	15.6	8.3	12.4	5.3	10.0	15.1	15.6
November	11.5	18.2	10.6	16.7	6.2	12.2	12.1	12.8
December	11.0	19.5	13.3	20.3	9.4	16.3	10.7	10.9
Total	100.7	178.4	104.0	168.8	83.7	155.2	123.3	136.1

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[1] The rainfall records of one of the largest companies near Kisaran show an average of 91.6 inches for 1917–1922, inclusive. The figures for Kisaran show a typical monthly distribution; but the amount of precipitation is somewhat below the average for the rubber districts.

The table below indicates the rainfall in three districts of Java

Month	Buitenzorg (13 years)		Tjipetir (8 years)		Bodja Semarang (6 years)	
	Inches	*Days*	*Inches*	*Days*	*Inches*	*Days*
January	16.2	25.7	11.1	22.3	36.5	20.3
February	14.2	24.0	12.6	21.2	35.5	18.3
March	15.7	26.1	10.3	18.6	32.1	16.6
April	16.4	23.4	10.9	19.1	36.5	13.4
May	17.2	18.6	9.6	14.8	16.8	10.6
June	10.8	14.8	4.8	8.1	10.3	5.5
July	8.7	12.5	2.3	6.6	12.5	6.0
August	8.0	13.1	3.6	6.7	6.1	5.2
September	11.0	14.3	3.4	8.3	7.3	3.7
October	16.8	20.7	13.7	16.4	6.4	7.2
November	15.6	22.8	10.4	20.1	16.5	10.8
December	12.6	23.9	12.5	21.1	27.5	14.3
Total	163.2	239.9	105.2	183.3	244.0	131.9

Rainfall in the various rubber districts of Ceylon

Month	Colombo (18 years)		Galle (40 years)		Ratnapura (40 years)	
	Inches	*Days*	*Inches*	*Days*	*Inches*	*Days*
January	3.50	10	4.29	12	5.37	12
February	2.07	4	2.82	7	4.42	9
March	4.67	11	4.51	10	8.97	16
April	8.30	16	9.87	16	12.33	19
May	12.68	21	11.29	20	17.78	22
June	7.97	21	8.32	21	19.81	24
July	6.43	17	6.13	19	12.79	22
August	3.13	14	5.37	19	12.12	22
September	6.22	17	8.21	18	15.14	21
October	13.20	22	13.33	21	18.69	23
November	11.79	19	11.44	18	14.59	20
December	5.37	13	6.79	15	9.01	15
Total	85.33	185	92.37	196	152.02	225

Month	Kurunegala (39 years)		Kandy (40 years)		Badulla (40 years)	
	Inches	*Days*	*Inches*	*Days*	*Inches*	*Days*
January	3.73	8	5.23	11	9.69	15
February	1.60	4	2.23	5	3.00	6
March	5.11	8	4.00	9	4.56	9
April	9.42	15	6.70	14	7.39	13
May	6.27	13	4.48	13	4.52	10
June	8.11	20	9.52	22	2.26	7
July	4.07	15	7.46	22	1.95	6
August	3.15	15	5.57	19	3.24	8
September	5.45	15	6.06	18	3.50	8
October	15.73	21	11.81	22	9.78	17
November	11.58	17	10.58	20	10.51	18
December	7.48	13	9.06	16	12.32	19
Total	81.70	164	82.70	191	72.72	136

There are frequent morning rains in Ceylon which interfere with the tapping. In some estates tapping is very irregular for about 3 to 4 months, because of morning rains. Violent cyclonic movements have occurred, but they do so only rarely and are not of the extent or intensity of those described here in the Islands as typhoons.

In Ceylon Para rubber flourishes very well below 2,000 feet and in a well-distributed rainfall of not less than 80 inches.

Rainfall in the various rubber districts of Burma

Month	Rangoon		Salween		Thaton	
1924	*Inches*	*Days*	*Inches*	*Days*	*Inches*	*Days*
April–May	11.71	18	9.85	14	27.51	22
June–September	89.91	96	105.44	106	198.85	103
October–November	14.30	20	10.81	19	8.03	12
1924–1925						
December–March	....	....	....	....	....	....
Total	115.92	134	126.20	139	234.39	137

Month	Amherst		Tavoy		Mergui	
1924	*Inches*	*Days*	*Inches*	*Days*	*Inches*	*Days*
April–May	25.05	25	17.85	15	19.43	22
June–September	172.90	106	156.44	105	117.99	92
October–November	5.60	13	13.17	10	31.93	22
1924–1925						
December–March	....	....	1.71	4	11.00	13
Total	203.55	144	189.17	134	180.35	149

1925	*Inches*	*Days*	*Inches*	*Days*	*Inches*	*Days*
April–May	19.58	18	12.55	15	....	....
June–September	77.53	96	90.04	105	....	....
October–November	10.06	11	7.11	13	....	....
1925–1926						
December–March	0.14	1	0.35	1	....	....
Total	107.31	126	110.05	134	....	....

1925	*Inches*	*Days*	*Inches*	*Days*	*Inches*	*Days*
April–May	40.61	22	23.35	22	18.74	22
June–September	198.37	116	176.90	104	130.10	99
October–November	2.10	9	12.59	15	12.05	19
1925–1926						
December–March	....	....	4.92	4	3.86	7
Total	241.08	147	217.76	145	164.75	147

In Burma as given on the above table there is a very distinct dry period commencing in December and ending in March, but rubber is profitably grown there although it has been observed that during this dry period the yield is lower. But this is compensated by less attacks of fungus diseases.

Rainfall at the D'Anloc and Dau-Clay Rubber Estates, Indo-China, for five years

Month	D'Anloc		Dau-Clay	
	Inches	*Days*	*Inches*	*Days*
January	0.6	2.0	0.9	4.7
February	0.3	1.5	0.4	1.5
March	2.2	5.2	2.7	6.8
April	3.0	5.4	3.4	8.4
May	10.0	14.8	10.6	16.4
June	11.0	19.0	12.9	18.8
July	15.8	22.8	17.6	22.8
August	15.9	22.0	15.0	20.8
September	14.2	21.0	15.6	21.8
October	9.6	17.2	10.6	21.6
November	6.3	8.8	6.7	11.4
December	1.4	3.3	1.5	5.0
Total	90.3	133	97.9	150

In general the rainfall of Siam is believed to be a little heavier and perhaps somewhat more uniform on the western side of the range of mountains running through the center of the peninsula than on the eastern side. At present rubber growing is to a large extent confined to the Patani and Singua districts, but it is said rubber can be grown as far north as Bandon except in those sections near Setul and Nakoru Sritamarat where the soil is too sandy. Southern Siam as far as Bandon not only enjoys a much greater total rainfall than is the case farther north, but the rainfall is distributed much more equitably, there being generally some rain at all seasons of the year.

Typhoons are practically unknown in the countries visited, but lesser storms occur occasionally, especially in Sumatra. The effects are given in the following table in one of the estates.

Date	Up-rooted	Top broken off	Branches broken off
May 5	85	58	184
May 30	200	500	300
January, 1924	872	1,046	....
April, 1924	14,200	6,311	....
August, 1924	1,347	1,533	....
August, 1925	750	734	....
June, 1926	4,060	....	....

In the afternoon of August 1, 1926, the writer witnessed a very light storm cause damage to over 3,000 trees out of a single block of 180,000 trees on the Goodyear Rubber Estates, Dolok Merangir, Sumatra. It is said that 2 years ago about 22,000 were injured in a storm.

Rubber has been found to grow best from sea level up to 2,000 feet and above this the growth is somewhat retarded.

Once established above 2,000 feet rubber is quite profitable, however.

LABOR

In Sumatra the laborers are mostly Javanese; but here and there Chinese and some free Bataks are still used for opening up plantations and the latter especially for weeding. The Javanese work in Sumatra under a three-year contract, which on expiration can be renewed for 13 months. The rate of reëngagements is about 90 per cent but in some parts still higher. The average wage is 35 centavos for man and 30 for woman with medical treatment, lower price for rice, and free transportation to and from Sumatra.

The laborers are housed in long wooden sheds with galvanized iron roofs, the floors of which are in some cases cemented, in others, however, not. The kitchens are frequently on the porch or just outside. Many of the laborers' quarters are very well located, i. e., on a hill near a good spring, not in the neighborhood of wood ravines, where malarial mosquitoes are bad.

There is a plentiful supply of labor in Malaya as in Sumatra, Java, and other rubber-growing countries. They are chiefly Tamils from South India, but Chinese are often employed also under contract. With improved conditions and the high prices of rubber and tin, the demand for Chinese laborers has increased and in 1925 alone there were 214,692 arrivals. The average Tamil wage is about 40–55 centavos per day for man and 35–40 for woman for eight hours' work, although the actual working time of a tapper does not exceed six hours. There was a move to increase wages of the laborers lately so that they might share in the benefits derived from the higher price of rubber, but this was objected to on the ground that it was believed that the higher the wages paid to the Tamil laborers the less days they would work and the more lazy they would become. Usually the housing facilities in Malaya are poorer than those in Sumatra. A total of 79,003 adults and 11,705 minors arrived in Malaya from India in 1925.

Labor in Siam is cheap and usually not very efficient, but could easily be supplemented by importing Tamil or Chinese labor.

There is a still more plentiful labor supply in Burma which could place that country in an enviable position as a rubber producer. The labor in most of the large rubber estates in Burma is composed of Koringis, Ooriyas, and Burmese. Indian labor is recruited from the coast. The wages of a skilled tapper range from ₱19.46 to ₱29.20 per man a month, and those employed in other manual labor, such as weeding and earthwork, etc., draw on an average of 55 centavos a day or 48 centavos plus ₱2.92 bonus for regular attendance during the month. Railway and public works contractors pay higher wages than rubber concerns. Hence planters are constantly sending agents to India to recruit laborers. The average cost of recruiting per head is between ₱19.46 and ₱29.20 but this amount is in nearly every case recovered from the laborer's wages.

Ceylon is wholly dependent upon Southern India for her farm labor. To defray the expenses of recruiting a fund is subscribed to by all of the estates in Ceylon according to the acreage of the estates and nature of the crop planted therein. The fees are at the rate of ₱1.10 per acre for tea and 37 centavos for rubber. Wages range from 25 to 55 centavos per day for man and 22–33 centavos for woman with low price for rice. It has been worked out by some rubber estate that one laborer is capable of maintaining a three-acre plantation. The importation of laborers has been increased steadily since 1921, and in 1925 alone Ceylon imported 226,909 laborers from Southern India.

While in all the countries visited the labor is plentiful and cheap, yet other items should be considered in the computation of their wages such as the expenses for importation, sanitation, medical care, allowances, grants for religious organizations, etc.

The average assignment for every laborer is about 6–7 acres including the factory and from this a proportion of one-third is woman's labor.

LAND AND SOIL

In the Malayan Peninsula the country is flat and low-lying for the most part, with a small range of mountains extending lengthwise throughout the peninsula, and the total area is approximately 56,000 square miles. Rubber plantations in this country are located both in the coastal and inland districts but inland plantations predominate. These districts are characterized as follows:

1. The coastal districts are mostly flat land and the fertile parts are largely set out to rubber and coconuts. Clay soil predominates, although peat, alluvial loams, and sandy soils are frequently met with. Drainage is a most important matter in these districts.

2. Inland districts are of the undulating and hilly type of lands and to a smaller extent flat plains and the soil is similar to that of Basilan Island in Zamboanga and has plenty of humus. Rubber occupies the major portion of the inland opened areas but mining and minor agricultural industries are well distributed although they do not cover so extensive an area as rubber. The original vegetation is a dense forest of heavy timber, but here and there "cogon" lands which were at one time planted with crops are found. The soils vary greatly, the most common being of a friable nature rich in humus. Another kind of soil is laterite.

The red clay loam is the typical rubber soil in Malaya.

In the east coast of Sumatra are found the so-called red soils of volcanic origin, while in some districts red laterite tuff and sedentary soil and white alluvial soils are also found. The soil is very light with numerous quartz outcroppings and owing to its loose nature soil wash is one of their great handicaps.

The soil at the H. A. P. M. estate in Sumatra may be described as white, flat or slightly undulating. The texture shows all variations from sandy soils to hardy clay. Except the sandy soils it exhibits the characteristics of a dry soil for a few feet below, being hard and compact, badly drained and poor in texture, lacking humus, and analyzing as follows:

Chemical analysis

Soils	Total N	Part per million in soil water		
		Ammonia	Nitrate	Nitrite
	Per cent			
From banks of stream	0.196	7	1.5	29
Do	0.109	Nil	2.0	20
Neighboring cement soil	0.076	9	Nil	Nil
Do	0.035	Nil	Trace	Nil

Besides this kind of soil there is also the red soil. This appears to have an excellent and well-balanced composition, the coarse sand and clay fractions predominating. The cement soils contain a considerable percentage of silt but, judged by mechanical composition only would not be classed as poor.

The soil noted in a low patch where good growth and luxuriant foliage of rubber were found lying along a stream bank was very clayey. The texture was fair due to a high percentage of organic matter. This soil closely resembled the coastal clays of the Federated Malay States where the white type soil is uncommon.

The brown loamy soil is of a somewhat unusual type consisting mainly of fine sand and coarse silt and is of excellent texture.

The mechanical analysis of the different soils in this estate is as follows:

Mechanical analysis

	Red soil			White soil sandy	Cement		White loam	Low soil Bor. Str.	Brown loam
	(6)	(7)	(9)	(14)	(11)	(16)	(3)	(13)	(19)
Coarse sand	18	33	37	47	1	7	14	0.5	8
Fine sand	24	9	6	29	14	14	41	3.0	32
Coarse silt	14	13	12	13	20	27	6	15.0	39
Fine silt	13	8	5	3	21	18	15	15.0	5
Clay	14	14	19	2	22	14	13	36.0	6
Moisture	5.5	7.5	6.5	1	6.5	5	2.5	10.0	3
Loss in ignition (partly organic matter)	12.5	9	10	3	10	8	7	15.0	7
Loss during analysis	1.0	6.5	4.5	2	5.5	7	1.5	5.5	......
Total	100	100	100	100	100	100	100	100	100

In this estate the best soils are classified according to their yields as follows:

1. Red soils—giving the highest yield.
2. Brown soil—giving a good yield.
3. White loam—medium yield.
4. White clay—lowest yield.

The effect of soil differences in rubber production and the formation of latex vessels as found by J. G. J. A. Maas and J. F. Schmole is quoted below:

Differences between the average production and the average number of latex vessels of 250 trees in the high part of the area and 250 trees on the lower part of the area.

Part of the area	Average circumference in inches	Productions		Latex vessels	
		Average weekly yield per tree in gram	Average weekly yield per inch in gram	Number in virgin bark	Number 1 year old renewed bark
High land	33 (111)	—46.60 ± 1.11 (157)	—4.36 ±0.10 (141)	—11.90 ± .21 (117)	—13.08 ± 0.21 (137)
Lowland	29.7 (100)	—29.63 ±[1]0.97 (100)	—3.09 ± .06 (100)	—10.18 ± 0.16 (100)	— 9.52 ± 0.13 (100)

The difference in yield is negligible as it was caused by the greater circumference of the trees in the higher area. There were more latex vessels in the renewed bark than in the original bark. It has been demonstrated that the rate of formation of latex vessel rings is influenced by differences in the soil.

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[1] Probable error of average.

The soil of Java is about the same as that of Sumatra. It is a rich, alluvial, volcanic soil that is more open than the soil of Ceylon and has very few stones. The major part of Ceylon soil where rubber is grown is quite poor and stony except in the Kalatura district.

Sumatra has an area of 175,000 square miles or is about seven times as large as Ceylon. It seems believable that if the whole island of Sumatra were to be planted to rubber it would be capable of producing the present world's rubber consumption, because the rainfall and soil are so suitable. As far as Java and Ceylon are concerned, one might say that no further development could be expected there with regard to the area of rubber. Borneo has an area of 300,000 square miles or twelve times the area of Ceylon. Sumatra and Borneo are highly fertile for rubber. Apart from some mountain tracts there are vast areas where rubber could be grown, it is said, and it is very probable that these will be planted in the near future.

There are large areas of land suitable for rubber in southern Siam as well as in Indo-China. In Siam there would be no difficulty in acquiring small tracts of land, either uncleared or already planted, suitable for rubber, but to get unbroken areas of an extent suitable for cultivation on a large scale would not be so easy. It is anticipated there would be difficulties not so much with reference to the matter of obtaining rights thereto in the case of Government-owned land as with reference to obtaining title from a number of small holders. That rubber may to all interests and purposes be raised as successfully and as economically in much of Siamese Malaysia as in the Federated Malay States seems to be adequately demonstrated.

Undulating land with loamy soil is found to be the best for rubber although it grows in about every type of soil but develops poorly on peaty land. In clay soil it requires deep and heavy drainage. As a rule, rubber does not yield there so well as in undulating land with open texture soil. The yield is good at first in heavy alluvial soils but does not exceed 400 pounds per acre, whereas on undulating land with open texture soils it yields from 600 to over 700 pounds per acre. Stony and very sterile soil is also considered unsatisfactory.

In Burma they allow people to cultivate the waste land for rubber without paying any premium and it is thereby exempted from the land revenue for eight years. The assessment after that date is at the rate of ₱2.92 per acre. The government, on the other hand, takes a 2 per cent royalty on the rubber exported after an allowance for the cost of production (₱1.05) has been made. The term of the grant is for thirty years and it is subject to revision at the end of that period; but the land revenue may not be increased by a percentage exceeding 50 per cent.

In Malaya the premium paid for jungle land is about ₱28.39 per acre. The land revenue rate is ₱1.135 per acre for the first six years, and ₱3.41 to ₱4.54 per acre for the remainder of the period. A royalty at the rate of ₱0.034 per pound is levied, that is, when rubber stands at a dollar (₱1.135) in Malaya, there is an increase in the land revenue after thirty years in Malaya as in Burma.

Preparation of the land.—In all the rubber-growing countries, cleaning the jungle land is done by what we call locally the caiñgin system and no attempt is made to remove the big stumps left after burning, and the cogon land by changkolling. (By changkolling is meant the turning up of the soil from 8–12 inches deep by means of the native hoe.) These methods of clearing jungle and cogonal lands are found so far to be the most economical methods for rubber plantations. The steps taken in preparing the jungle land in the majority of cases when rubber is planted in jungle land are as follows:

1. Cutting the small bushes.
2. Cutting the big trees—jungle felling.
3. Heaping and burning over the cut areas. Jungle badly felled, and the branches not properly cut and piled would result in a bad burning and much expense would be the result in clearing up.
4. Construction of roads. Good roads have been constructed by the Government in all rubber countries and water supplies and medical supervision furnished by the planters, which both contributed to the rapid developments of the rubber industry there. Upkeep: one laborer per 1,000 meters macadamized road and one per 3,000 meters for second class road.
5. Changkolling and pulling out of the smaller stumps to 1½ feet deep. A man can finish 120 sq. m. a day. In changkolling heavily cogon land it took 1,533 men days per acre and on light cogon 52 men days.
6. Building of catch drains, terracing the land, banding and drainage for low land.
7. Sowing of cover crops.
8. Weeding. Weeds are hoed out as they appear. After burning, weeding follows and if the weeds have been kept under from the beginning saving will be affected.
9. Lining and digging of holes.

10. **Fencing.** Fencing is rarely done in rubber estates except to exclude wild pigs and deer.

In rubber planting the removal of stumps is believed to be a most important thing to be taken into consideration, since dead wood gives rise to fungus diseases, especially root diseases which affect rubber badly. This is done thoroughly in many estates while others take chances on diseases, but have since found it to be more expensive to keep the plantation free from diseases than to remove stumps at the beginning in many cases. The quicker all jungle wood is removed by deep changkolling the less the loss from diseases. Because of the cheap labor the stumps are removed by hand, especially the small ones, during changkolling.

The following table shows the results obtained by the tractor *versus* the hand-stump puller in Sumatra.

Item	Cost per stump in guilder cent[1]	
	Tractor	Hand stump puller
Labor	0.06	0.24
Bonus to laborers	0.01	0.05
Depreciation and upkeep	0.25	0.05
Total	0.32	0.34

[1] (G. 1=₱0.804)

The average number of stumps pulled per day by a tractor is 220 and by each hand stump puller 20.

No plowing is done preparatory to planting, but the land is changkolled to more than one foot deep and all small stumps removed during the course of the work, then weeded from time to time and cover crops planted.

In digging holes in hard cement soil explosives were used and the following yields were obtained at the H. A. P. M., Sumatra (the yield based on 100 per cent control).

Treatment	July	August	September	October	November	Average
Explosive 1 cartridge per tree	94	100	98	84	101	95

It appears from the above data that no increase in yield was obtained from the treatment. The loosening effect of the explosives in the soil had to all appearances disappeared after two months.

Practically all this work in the preparation of the land before planting is done by contract labor.

Drains.—No irrigation is practiced in any of the rubber-growing countries because of the uniformity of rains. However, special attention has been paid to the construction of drains, main, and lateral. In Ceylon, Indo-China, Burma, and part of Malaya the backwardness of many rubber estates is due largely to lack of drainage. The surface soil has been badly washed away by heavy rains and only hard and baked subsoil left. Trees in such areas have suffered from diseases, the bark renewal is slow and the yield has fallen off considerably. Attempts are now being made to remedy the situation by building silt pittings, contour drains, and terracing which have resulted in a general improvement of the crop. On flat coastal areas where the percentage of heavy clay alluvial soils is high the main drains are sometimes dug 7 feet below the level of the land and of the same width, and the small drains are of varying sizes and between the rows of trees, while on undulating and hilly land contour drains, silt pittings, or catch drains to hold back the rain water and to prevent soil erosion have been built. In Java and Sumatra for a catch drain 6 feet long, 2 feet wide, and 1½ feet deep they spend ₱1.045 per acre, and less on ordinary drains. They are built 6 x 2 x 2 feet where the water accumulates during the early stage of planting or before planting. In constructing a drain it should be borne in mind that it needs to be capable of removing the surplus water within 24 hours, except in exceptional cases. The number of minor drains depends upon the texture of the soil, and this should be arranged in such a way as to allow the removal of the surface water in two days. The drains are kept clean, and during the dry weather the debris that accumulates is burnt. Terraces are built on steep slopes and laid according to the contour of the land. In terracing the planting of cover crop and grass in the slopes other than cogon is undertaken. Terraces made one below the other 10 to 20 feet wide and with cover crops planted between the terraces have prevented soil wash on steep soil, but the cost is great (₱64.32).

Cover crops.—Formerly in Malaya as well as in Java and Sumatra nearly all the estates were cleaned and weeded, but now cover crops are being grown largely instead. Throughout Java, Sumatra, and Malaya practically all the rubber plantings are cultivated on the contour system and evidently that has been found very helpful in the conservation of soil and as a result there has been a good bark renewal. Cover crops are universally used. A suitable cover crop has been planted everywhere immediately after changkolling. Among the numerous cover crops, the *Vigna,* the *Calopogonium,* the *Centrosema,* and the *Pueraria javanica* are the most common in Java, Sumatra, and Malaya. Apart from soil erosion the new system is valued as a means of water conservation, lowering the cost of weeding, and even in the old fields platforms and water traps are being cut. In certain areas of old washed-out soils *Albizias* are being used and there is evidence that these trees assist reclamation.

Mimosa invisa, which is closely related to the "macahia" in the Philippines, is planted in new clearings, and is said to be an excellent soil rejuvenator; but because of its many long thorns it is not used as a cover crop for rubber. However, it is planted almost everywhere where cogon adjoins the estates, because it is quickly established and hardy, as a barrier to prevent the cogon from encroaching on the crops under cultivation.

Calopogonium mucunoides is the most popular cover crop in young areas and grows well in all kinds of soils. The stalks do not become woody and the plant always remains so tender that there is no danger of fire in a dry time. The *Centrosema pubescens* is also a very good cover crop for young rubber planted at the rate of 2.6 kilograms of seed per acre. It grows more sturdy than *C. plumieri.* At first it grows very slowly, but when it is established it forms a very thick cover. It has also been attacked by *Rhizoctonia,* but the damage was considerably less than with *Vigna.* It needs to be kept clean of weeds.

Calopogonium grows in the open and is not tolerant of shadow. It is a very nice cover crop as a humus former, but it grows too high, making walking very difficult and allowing cogon and weeds to get a good start before they are detected.

Dolichos Hosei or *Vigna oligosperma* stands moderate shade in rich soil but not in poor soil. It can best be propagated by cuttings, which cost ₱4 per acre. It is a fairly good cover crop for old coconut and rubber plantations when half shaded. It has given the best results throughout the year in Sumatra both with old as well as with young rubber trees, but it is attacked by a wet-rot disease during the rainy season. This disease attacks both the twigs and leaves, and in badly infected fields the plants left do not cover the ground and instead only weeds grow.

Forking accelerates the growth of the *Vigna* during the dry season and makes the disease less troublesome.

Ferns are another popular cover crop in Malaya and Sumatra, providing an effective cover for soil wash, but they should be cut once in a while to prevent too tall growth. They check cogon and keep the soil in a soft and moist condition. They are not harmful provided they are not mixed with noxious weeds and are cut back occasionally. Cutting is done at the beginning of the rainy season.

Phaseolus lunatus has given poor results, while *Portulacca* has proved to be a very good cover plant under young rubber. In places where this bean was planted rubber has made a growth of two months ahead of that where there was no *Portulacca.* This plant does not thrive in the shade, and its principal drawback is that it does not benefit the soil and does not spread well on poor soil.

Indigofera hirsuta, Cassia mimosoides, Crotalaria alata, C. usaramoensis, Tephrosia villosa, Canavalia ensiformis, and various bush beans were tried but with poor results. *Albizzia moluccana, Boea macrophylla,* and *Gliricidia* are now under trial.

The planting of cover crops has taken the place of clean cultivation formerly in practice. The extensive planting of cover crops began in 1920–1922 due to the slump in price of rubber, which necessitated economy in running the plantations. The main object at that time was to reduce the cost of weeding, but besides the planters found out other values of cover crops, such as soil preservation and moisture, the addition of humus in the soil. etc. And it has been proved that by green manuring and cover cropping the yield of 23-year-old rubber has been increased.

Because of this soil conservation by means of contour planting and the use of green manures in Java and Sumatra, the yield has been much increased and good bark renewal has been better in Ceylon and Malaya under similar conditions.

PLANTING

Nursery.—On the majority of the estates planting is done direct in the field while in others seedlings are grown first in raised beds and then transplanted either on stumps or in baskets. The soil in the nursery is dug up to a depth of 1 to 1½ feet before sowing the seeds thickly. The hilum of the seed (the flat side) is laid down on the soil to absorb the water rapidly and to produce straight tap roots in some of the estates. The seeds are kept moist by constant watering particularly for the first few days and covering them with rice straw, gunny sacks or other similar materials. In some cases a temporary shed is constructed to prevent excessive light. When the seeds begin to sprout, in about 6 days or at most 21, they are pricked to other beds if to be planted by stumps or in baskets if to be planted in baskets.

In all cases, however, seeds are planted while fresh, since they lose their vitality within a short time. Seeds are collected daily or at least every 2 or 3 days, and then put under shade to prevent them from drying out. Harvesting fruits from the tree for seed purposes has been objected to because of the possible premature development of the resulting plants. Seeds that fall at the end of the seed season usually have a very low percentage of germination. Heavy, well-filled and firm seeds obtained from high yielding and mature trees are selected for seed purposes.

The table below shows the loss of vitality of selected and unselected Para rubber seeds at the H. A. P. M.

Kind and number	For 1 week	For 10 days	For 11 days	For 12 days	For 13 days	For 2 weeks	For 15 days	For 16 days	For 17 days
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1,099 seeds (selected)...	5	15.28	24.56	37.21	43.49	48.40	49.77	53.14	55.50
112,572 seeds (unselected)	....	0.40	2.19	6.89	16.46	25.97	32.94	37.27	39.58

Kind and number	For 3 weeks	For 4 weeks	For 30 days	For 5 weeks	For 6 weeks	For 7 weeks	Remarks
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	
1,099 seeds (selected)....	58.50	66.50	67.69	72.88	78.00	78.50	No further germination after 7 weeks.
112,572 seeds (unselected)	....	....	....	....	....	....	After 17 days the beds were cleaned up.

Seeds not promptly gathered from the ground give a germination test of 31 to 36 per cent only, while those picked from the trees give 56 to 70 per cent. Seeds gathered from the trees and selected in weight have given in 17 days about 16 per cent more than unselected seeds not picked up under the trees.

Another germination test of selected versus unselected seeds has been undertaken on the same estate as shown in the following:

UNSELECTED SEED

Number of seeds planted	683,226
Number of seeds germinated	210,892
Percentage	31

SELECTED SEED

Number of seeds planted	217,972
Number of seeds germinated	123,241
Percentage	56

Seeds that were not planted at once or those for shipment were preserved as follows by the H. A. P. M.:

Table showing the results of packing Para rubber seeds for shipment

FIRST TRIAL

	Method	After 3 months Germination in Costa Rica	 Germination of control in Sumatra
		Per cent	*Per cent*
1	Micropyle closed with paraffin, packed in moist powdered charcoal and sand 3:1. Cold storage. In wooden box lined with oiled paper	....	4.0
2	Packed in moist charcoal and fine soil of equal parts in wooden box lined with oiled paper	6.9	69.5
3	Packed in moist and dry preservatives containing 3 parts charcoal to 1 part of soil in wooden box lined with oiled paper	9.3	[a]56.0 [b]73.5
4	As No. 3 but micropyle with paraffin	15.6	3.0
5	As No. 3 substituting sawdust for soil	2.8	47.5
	Fresh seed before packing	....	75.0

[a] Dry part. [b] Moist part.

SECOND TRIAL

Method of packing	50 seeds Number of good seeds	 Per cent good	Germination test March 14–20	 March 21–27	 March 28 April 3	 April 4–10	 April 11–17	Total Number germinated	 Per cent germination
Three parts charcoal to 1 part soil, kept in cool place:									
A–500 dipped in latex	16	32	1	12	......	1	1	15	7.5
B–500 micropyle closed with paraffin	25	50	......	......	5	2	1	8	4.0
Equal parts of charcoal and soil:									
A–500 seeds	36	72	......	129	2	5	3	139	69.5
B–500 seeds wrapped in oil paper	29	58	......	33	2	4	......	39	19.5
Three parts charcoal and one part soil:									
A–Upper half dry	22	44	27	80	3	1	1	112	56.0
B–Lower half moist	28	56	27	115	2	2	1	147	73.5
Three parts charcoal and one part soil:									
A–500 seeds micropyle closed with paraffin	4	8	......	5	1	......	......	6	3.0
B–500 seeds dipped in latex	......	......	......	3	1	......	......	4	2.0
Three parts charcoal and one part sawdust	25	50	......	93	1	1	......	95	47.5

Seeds packed in various ways were kept for a period of three months. This indicated that rubber seeds should be kept moist. Three parts of charcoal to one part of soil when properly moistened was found to be the best packing material after three months and an equal mixture of charcoal and soil gave better results than an equal proportion of soil and sawdust. The highest percentage of germination after a period of 3 months - was 73.5 and the lowest was 2.8.

In the second trial the seeds were picked from the trees December 13th and packed December 14th except those dipped in rubber latex that were packed December 17th. In each case the packing material was used as wet as possible without having water run from the box. Both dry and wet packing materials were used and the wet proved the best.

Seeds packed with moist sawdust gave 50 per cent germination after a period of 10 to 15 days in the boxes.

Seeds for shipment were not packed in air-tight or close-soldered containers lest they suffocate and mould. The cases used were not larger than 50 by 40 centimeters and made of strong wood, i. e., 15 millimeters thick with straightened ring pieces at the corners. Lining the cases in the inside with oil paper or any similar packing paper has been found very good and also dividing the contents when filling by several folds of stiff paper into three or four layers. Coating the seed with wax was found good but too laborious. Dipping the seeds in alcohol and then setting them alight killed a proportion of the seeds. Dipping them for about two seconds in warm water was bad too, but dipping them in sublimate had a light advantage, but disinfecting damp seeds with sulphur dioxide had a bad effect.

Moist coconut dust mixed with soil or powdered charcoal was found very serviceable or a pure slightly moist clay soil as packing materials when used liberally.

In plantation practice, the seeds are kept good for 1 or 2 months by burying them in soil. Keeping the seeds in this way a germination of 80 per cent was obtained and 10 to 20 per cent of the seeds germinated during the course of the trial. Seeds stored in a temperature of 5° to 10° C. maintained their germinative power very well. Bottles or tins were also found to be good seed containers, in which case no packing materials were necessary.

Pricking.—Various opinions exist as to what is the proper time to prick rubber seedlings. Some claim as soon as the tap root appears while the auxiliary roots have not yet grown. This is to prevent the lateral roots from being damaged. A considerable loss in beds—say 20 per cent—has been experienced besides many of the seedlings show abnormalities because of the sun's rays. Others believe that the best time is when the auxiliary roots are about two centimeters long, but in the majority of cases it is done as soon as the stem has established itself in its normal position and this way seems to be the best. Pricking is done in raised seed beds.

Vegetative propagation.—By propagating with unselected seeds a young plantation will consist of many bad and a few good yielders, and so to a degree even with selected seeds. The only way of obtaining a plantation of high-yielding trees grown from seeds is to follow regular plant breeding methods, that is, first grow a type which has all the desired qualities, and must breed true to type and then cross this with another similar type. This takes too long, but the difficulty may be overcome by vegetative propagation, where no cross fertilization can occur between good and poor yielding trees as in the case of seeds.

Budding.—The Dutch in the East Indies have taken up the question of the budding of rubber and the question of yield rather extensively, and whereas in Malaya, Ceylon, Burma, Indo-China, Siam as well as in the Philippines the planters seem to be satisfied with the policy of wait and see, the people in the Dutch East Indies have gone ahead and tried.

Budding rubber in Ceylon was started in 1919, by Mr. H. W. Roy Bertrand. This work has not progressed rapidly. There are only about 8,900 budded rubber trees in the whole island of Ceylon, and 4,600 of these are owned by Mr. C. E. A. Dias. Their ages range from 2 to 57 months, and they are not from selected clones (clones are group of trees raised from one mother plant).

It appears that the total acreage planted to budded and selected seeds is between 50,000 to 100,000 acres in the Dutch East Indies. In Sumatra, one company alone has planted about 23,000 acres with mixed budded plants and selected seeds. All future plantings will be with selected seeds and buds.

The method popularly used in Sumatra and Java is the half Forckert system or what is commonly known in some estates as modified patch budding. The principal methods of budding have been tried with rubber, namely, the Forckert, the patch, and the shield budding.

Forckert budding.—About two or three inches above the ground level a rectangular incision is made and the bark is stripped off leaving the lower end of the strip attached to the trunk. The piece of bark so freed from the trunk is about two inches long by half an inch wide. A similar shaped piece of bark containing a bud is taken from the budwood nursery and is inserted between the cambium and the bark that has been partially removed from the plant. The small piece of wood that may be cut away with the bud is removed before inserted in the stock. The original bark is brought up again so as to keep the budwood bark in position and the whole is bound together by means of strips of banana fiber two inches wide by about one and a half yards long, this bandage having been treated with yellow wax. After the lapse of two weeks the bandage is removed and the bud examined, and a week after the stock is cut off about 10 to 15 centimeters above the bud. About one week or ten days before the plant is actually required for removal to the field the stock is cut six inches above the bud. After planting in the field care has to be taken to note whether the bud that shoots out is the one that has been grafted on. If young buds are observed sprouting from the stalk these have to be removed in order to encourage the high yielding bud to shoot out. When this bud shoot is well established and about two or three feet high the stump is sawed off close and the wound waxed and tarred or some wood preservative applied.

The table below indicates the results of the different methods of budding rubber in Sumatra.

Method	Number budded	Success		Average time per budding
		Number	Per cent	
				Minutes
1. Plate budding	600	[a]179	89	2.68
2. Reversed T-cut	100	100	100	1.40
3. T-cut	200	144	72	1.21
4. Forckert method	200	151	74	1.11
5. Reversed T-cut with growing bud	602	[b]60	60	1.12
6. T-cut with growing bud	100	Not yet open.	....	1.10

[a] Up to date 200 were inspected of which 179 were successful.

[b] One hundred were inspected of which 60 were successful.

From the result it appears that budding rubber is quite an easy operation, but that the reversed T-cut with dormant buds gives the best results, while it is also a reasonably quick method. All buddings were done with dormant buds unless stated to the contrary. This of course requires a very large number of trees from which to draw material, since a budwood has been found to produce only about 22 buds per meter.

All buddings were done as close to the ground as possible to get the advantage of the scion. Budding lower to the ground is better and 95 per cent success could be easily attained. Budding on the tap root if not for the danger of the standing water in the ground would be equally good and would not produce the "elephant foot" at the union of the scion and the stock. However, because of the water the plants would rot while still in the nursery beds. Budding has been done in the nursery as well as in the plantation. Poor results were obtained during the driest months. About 90 per cent of success was usually obtained in the nursery, while in some cases even 100 per cent. In the field usually the percentage of success was lower—about 50 to 60 per cent of success only with two or three plants to a hole.

In field practice, the following results were obtained in Sumatra:

Estate I

Month	Budded plants	Successful	Success
			Per cent
1923	97,138	73,193	75.3
1925:			
August	25,826	19,067	73.8
September	42,813	20,616	48.2
October	45,494	28,890	63.5
November	15,697	14,120	92.4
December	24,303	12,719	52.3
1926:			
January	23,609	8,858	37.2
February	22,509	11,350	52.3
March	17,458	6,363	36.6
April	19,854	7,754	39.1
May	18,574	11,119	59.9

Estate II

1921	498,622	109,252	22.0
	154,516	34,869	23.0
	12,114	6,247	51.0
	609,259	287,412	46.0

Estate III.—Thirty-three per cent, 50 per cent, 64 per cent, and 80 per cent were obtained.

Stock and scion.—Seedlings raised from selected trees and budded at the age of 8 to 18 months have been found to make the best stocks. The stock plants in the nursery were planted 1½ by 1½ feet apart, and there were three or four rows with a path between the seed beds. Young branches of old stumps and 7-year old stocks were also budded occasionally. Budding with

3-year old stocks gave 2 per cent success. Budding 4-year old stocks gave the following results:

1. Budding on opposite sides of the trunk under the first branches—0 per cent.
2. On opposite sides of the trunk at 3 to 6 feet high—23 per cent success.
3. On shoots—51 per cent.
4. On bigger branches—2 per cent.

It has also been observed that budding on budded plants cannot be done with any reasonable success.

The best stock so far found in Java is a cross between *Hevea spruceana* and *Hevea brasiliensis.* This hybrid stock is resistant to moisture and has a more vigorous growth. *H. collina* and *H. guyanensis* are under trial for stock. They could be budded with *H. brasiliensis.*

Branches of all thicknesses have been used as budwoods, but green buds gave poor results. Eighteen months was found the best age for budding. Blind or dormant buds are considered to be best for use as otherwise in sprouted buds the wood is already attached with the bud. Scions obtained from the terminal and lateral growths showed no difference in the character of growth as do coffee and kapok.

Experiments are now under way at Buitenzorg to find out the influence of the stock on the scion and vice versa. The stocks have been budded at different heights, but no conclusive results have been reached as yet.

Lopping test of stock.—The following results have been obtained so far:

1. Cut about 8 inches above the union—70 per cent success after 3 months.
2. Ringed at 6 inches above the union and broken off or roughly cut off at about 6 feet above the ground—80 per cent after 3 months.
3. Ringed—only 69 per cent after 3 months.

The best result was obtained from the second which had 17 per cent more sprouts than the first. At the beginning the third appeared to be equal to the second, but dropped 11 per cent after 14 weeks and from then on remained at the same stage as the first which after 18 weeks was 15 per cent below the best.

Importance of budding.—Besides the mother plant coming true to type by budding, it has been found on budded plants:

1. That a high tapping cut up to 9 feet gives the same yield as a lower cut.

2. That two cuts in one-half circumference 42 inches apart in the same tree give practically double the yield of a single cut.

3. That with a heavy tapping system such as the above 2 cuts, alternate week or alternate two weeks tapping is superior to alternate monthly tapping.

4. That the budded plants as a whole have shown better growth than the seedlings, the former having increased 2.5 inches in girth and the latter 2.1 inches only, other clones increased 3.7 *versus* 3 inches at 4½ feet height, but that the increase in bark thickness has been better for the seedlings than for the buddings, .029 *versus* 0.23 inch.

5. That budded plants were not so susceptible to brown bast as the seedlings—25 per cent *versus* 35 per cent.

6. That some of the budded plants produced no seeds, but their vegetative offspring have seeded.

7. That the budded plants compared favorably with the non-budded plants as regards the number of latex vessel rows.

Budded vs. selected seedlings in Sumatra.—One hundred twenty plants were planted to the acre in 1920 and tapped for the first time in June 1925. The yields were as follows:

Materiais	Acres	Trees per A in tapping December, 1925	Yield per acre in pound of dry rubber			
			First month	Second month	Third month	Fourth month
A–Selected seeds mixed with budded plants	115	78	18	35	40	46
B–Budded plants	65 185	72	36	39	52	59

The result shows the advantage of budding over selected seedlings.

The 68 acres of budded plants at 200 trees per acre planted in alternate rows of buddings and selected seedlings at the H. A. P. M. in 1921 were trial tapped for one-half month with a one-half cut. The buddings tapped at 40 inches and the seedlings at 18 inches gave the following results:

Average yield over 9 days in cubic centimeter latex	Number of seedlings	Number of buddings
0— 5	99	20
5—10	439	170
10—15	311	318
15—20	171	236
About 20	184	439
Total	1,204	1,183
Average in cubic centimeters	12.5	17.2

In A. V. R. O. S., Sumatra, the results of tapping budded plants against seedlings are reproduced hereunder:

Experiment 1

Clone	Buddings A	B	C	D	E	F	Seedling
Number of trees	7	6	5	4	2	2	50
July 5—August 7, 1922 tapping height 0.45 M	70	160	133	101	242	91	100
June 10—July 11, 1923, tapping height 0.40 M	92	143	159	96	192	85	100
September 12—October 15, 1923, tapping height 1 M	99	113	195	170	152	94	100

The scions were obtained from unselected trees. Clones A and F were poor yielders. While the rest surpassed the seedlings. Only wood from selected mother plants is to be used for scions, then.

Experiment 2

Kind	First yield per tree		Second yield per tree		Average	
	Grams	Per cent	Grams	Per cent	Grams	Per cent
Seedlings	2.58	100	6.64	100	4.61	100
Buddings	3.06	118	6.26	94	4.66	101

The yields of the seedlings and the buddings from unselected clones are about the same.

Experiment 3

		Seedlings			Budding clones		
		Cross 36 x 35	Illegitimate 49	Selected seed	49	35	27
July, 1926	Number of trees	26	14	214	112	228	103
	Grams per tapping per tree	24.4	19.4	7.1	20.7	15.6	12.2
September, 1926	Number of trees	22	14	214	109	226	102
	Grams per tapping per tree	29.2	20.0	8.4	23.3	20.5	15.3

The results show the importance of selected seeds and clones for scions. The buddings from good clones were much better than seedlings from selected seeds in the plantation, since they gave better yields than the seeds of the same age.

In Sumatra they got a yield of as much as 10.31 pounds per tree a year from the budded plants as compared with 4.67 pounds per tree from the non-budded plants. The best clones were expected to yield 700 pounds per acre or more at the age of 5 to 6 years old.

The yields of 6-year seedlings and 5½-year budded plants were compared and gave the following results at A. V. R. O. S.: The average yield of the seedlings was 8 grams per tapping, while clones 33, 36, 50, 52, and 80 gave 14.65, 11.16, 20.11, 12.98, and 13.04 grams, respectively.

The yields of budded trees *versus* seedlings in one of the estates in the Federated Malay States as compiled by the Department of Agriculture, is tabulated below.

Date	Clone	Number of trees	Yield		Remarks
			Latex	Dry rubber	
			Cu. cm.	*Grams*	
December 3, 1925	1	17	1,283	293.4	Average girth 17 inches from the ground 21.66 inches. 16 trees split.
December 9, 1925	1	17	1,164	298.2	
December 11, 1925	1	17	1,161	291.2	
January 8, 1926	1	17	1,078	264.8	
January 12, 1926	1	17	850	226.1	
Total			5,536	1,373.7	
December 16, 1925	1 and 9 mixed	15	1,491	358.2	One split average girth 17 inches from the ground was 21.18 inches.
December 18, 1925	do	15	1,379	311.3	
December 22, 1925	do	15	1,083	268.6	
January 7, 1926	do	15	983	231.0	
Total			4,936	1,169.1	
December 16, 1925	Seedlings	15	372	107.5	Average girth 17 inches from the ground was 22.8 inches. One not tapped.
December 18, 1925	do	15	378	96.1	
December 22, 1925	do	15	285	85.1	
January 7, 1926	do	15	307	65.7	
Total			1,342	354.4	

The stocks used in this experiment were not selected but the scions were obtained from selected mother trees in one of the estates but no records of yields were obtainable. The controls were 5-year old trees. They were all grown in virgin jungle, undulating, light clay loam soil, cover-cropped during the early stage, and catch pits were dug. They were budded in October and November 1921. From budding the age was approximately 4-year old, distanced 20 by 20 feet. Tapped in August 1925, one-half spiral daily 20 inches from the ground for five weeks and rested for similar period. In November 1925, the system was changed for alternate daily. The bark consumption was 4 inches for 2½ months, 310 trees per tapper and tapping began at 6:10 a. m. There were 160 tapping days a year and 80 trees to the acre. The yield of clone 1 averaged 16.3 grams, the highest 24.5 grams and the poorest 9.1 grams per tapping. In mixed clone 1 and 9 the average was 19.9 grams per tapping, the highest 28.7 grams, and the poorest 12.3 grams. In the control the average was 5.8 grams per tapping, the highest 12.6 grams and the lowest 2.3 grams.

Other estates have the following results to show for their budded trees. Estate I, for example, recorded a yield of 2.106 pounds dry rubber per budded plant for 7 months compared with 1.369 pounds of non-budded plant or 153.8 per cent extra.

Estate II.—The six best clones of the oldest budded trees yielded an average during their 6th and 7th years 12 pounds per tree, the best averaging 15.9 pounds against 8.2 pounds and 10.3 pounds of other clones, respectively, in the 5th to 6th year. The preliminary yields of the younger approved clones gave indications that they would equal and possibly exceed the yields of the older clones.

Accurate comparisons of selected seeds against buddings over lengthy periods are still lacking but a plot of 12 acres planted in 1921 with alternate rows of improved budded and selected seedlings yielded in 10 days of test tapping 38 per cent more latex from the budded than the seedlings.

Objections to budding.—Some believe that the latex is watery. What the writer saw was not. The bark of the budded plant was thinner than that of the seedlings, but they obtained the yield from it, which is the main thing. Bark renewal was a bit slower—8 months for seedlings, and 12 months for budded rubber. Untested trees were useless for scion purposes. There was a very large demand for scions from selected mothers. The Dutch paid from ₱0.804 to ₱3.216 per meter scion and in Ceylon ₱0.735 and for budded plants from ₱0.92 to ₱1.102 each.

Cost of budding.—A laborer buds only 200 plants in a day. One successfully budded tree cost about 3½ centavos on one of the estates. In another estate out of the 609,259 budded plants 287,412 were successful, making the cost of ₱19.063 per 100 successful buddings. The cost per budded plant, labor and materials only, as recorded in this estate, was 3 centavos. A detailed list of expenditure incurred in the above estate is given hereunder:

1. Labor of actual budding 4,566 days' task at 73.6¢ (all in cost of day task)	₱3,377.38
2. Premium on buddings	456.88
3. Other labor 3,652 days' task at 73.6¢	2,701.31
4. Materials	3,357.96
Total labor and materials only	9,893.53
5. Budwoods	2,818.03
6. Transport charges	2,079.06
Grand total	54,790.61

Cuttings.—Propagation by cuttings has never proved feasible with rubber as very few of the cuttings produced roots. The following conditions were tried.

1. From green wood, ends of branches, planted in ordinary ground, outside.
2. Cuttings from 1-year old shoot, planted in ordinary ground outside.
3. From half green and half 1-year old shoots, planted as before.
4. From green side shoots, with a little piece of the old branch, planted as before.
5. From green wood, cut made where green and old wood meet, planted as before.
6. From heavy green shoots, cuts of shoots, planted as before.
7. From heavy green shoots, tips cut off, planted as before.
8. Green side shoots, with little piece of the old wood, planted in coarse sand under shade.
9. Green shoots, end of branches, planted inside as before.
10. Heavy green shoots, end of branches, planted inside as before.
11. Shoots, which had little side shoots, the latter broken off, planted inside.
12. Two-year old branches, laid horizontally in ground, shoots formed and ringed.
13. Same as 12, but 3-year old branches, 3 shoots formed and ringed.
14. Lower portion of heavy green shoots same as 7 but planted inside.
15. One-year old shoots, same as 2, but planted inside.
16. Young tips, with 2 or 3 good leaves, planted inside.
17. Young tips, just starting to grow, planted inside.

Of the above conditions, cuttings No. 5, 6, and 11 remained green for quite a while and Nos. 7, 14, and 15 only for a short time. Cuttings from trees 1 to 1½ years old were apparently better than those from old trees. With this young material some success was obtained, but not much. Experiments prove that it is better to ring or girdle the cutting beforehand to allow it to callous in order to secure more food in it. The top of the cutting is waxed or tarred and it is placed sufficiently deep in the ground. In this way 10 to 15 per cent of the cuttings have rooted in 3 to 4 months.

Grafting.—Cleft-grafting, side-grafting, and crown-grafting were tried.

Forty per cent success was secured in cleft-grafting. But the process requires too much care to be of any practical value. Moreover, the growth is not very good, at least in the beginning. Waxed cotton cloth was also used for binding purposes and the operation has been done under grafting tubes.

Fifty-five per cent success was attained in side-grafting. It was simpler than cleft-grafting. Young top-scions were used and no grafting tubes were employed. Grafting tape was used for tying.

Seventy-five per cent success was obtained in crown-grafting. Young top-scions were used. Grafting tape was employed for tying. In the beginning the young scions were protected from the sun.

In one of the estates in Sumatra they got 100 per cent success from 1 to 4-month old scions on 4-year old stocks, which indicates that this is one of the easiest and most successful methods of vegetative propagation on Hevea.

Marcotting.—The branches to be marcotted were ringed off and here the cambium layer was peeled off. A mixture of cowdung, clay and coir-dust was put around the wound and then uncleaned coconut bark. To prevent drying a filler made from a banana leaf or waxed cotton was employed. Marcottage appeared to succeed best on ½ to 1½-year old plants. It is said that marcotting does not succeed well on branches of old trees. Of the 127 marcots made in June 1923, 70 are in fair condition, as to root formation, vitality, etc. This amounts to 55 per cent of the total. These were transplanted October 1924, and by December only 20 remained, which was only 15.8 per cent of the number made. It has therefore been decided that marcotting is of no value as a practical method of vegetative reproduction for Hevea.

Transplanting.—Planting in the outside field was done either by seed-at-stake (germinated or not germinated first), by basket, or by stump. The first is the most popular method because of its cheapness in plantation practice. Two or three seeds were dropped in each hole, then the plants thinned later by removing the two weakest seedlings. This was considered a good method provided rats and certain insects which attack the seeds in the field were not numerous. Planting seeds direct gave from 25 to 85 per cent germination with an average of 45 per cent. In transplanting by basket the seeds were allowed to sprout first in nursery beds, then pricked direct into the basket where they were allowed to stay till they were ready for the field—usually about 4 to 6 months. This method is considered the best but it is very expensive. The stumps were nothing but semi-overgrown seedlings in the nursery about 6 to 12 or more months old and these were used for planting only when they were short of planting materials. In the past, nearly all planting was done from stumps from nursery grown plants.

These were pulled up carefully, cut off at about 2 feet from the collar, the tap root also cut and then planted out in holes previously made. At first the over-grown seedlings were cut to the ripe wood and as soon as the buds began to develop, but before any leaves were formed the stumps were pulled up, the tip of the tap root and the injured lateral roots removed and the stumps transplanted to the spot desired. Transplanting with a ball of earth gave a very encouraging percentage of live trees.

In a few cases valuable trees 3 to 4 years old were also transplanted with 90 per cent success. Before planting, the limbs were cut off and on smaller trees some branches and the lateral roots were left undisturbed except the injured parts. The tap roots were left as they were and neither the main lateral 1 to 2 feet long nor any other root was allowed to dry off.

In setting out the lateral roots the plants were not covered beyond 9 inches below the surface of the ground, since the roots are surface feeders and in shallow water table soil practically no tap root is formed.

The holes were dug 2 to 3 weeks previously about 1½ feet deep or 4 by 4 by 4 feet or 2 by 2 by 1½ feet or according to the size of the plant to be transplanted. On one of the estates an experiment to determine the difference in growth of trees planted in holes 3 feet deep and in ordinary changkolled ground has been carried out and the growth turned out to be the same in both cases.

In Ceylon an experiment was carried out of planting rubber in holes blasted with dynamite and ordinary holes dug by hands. The results are as follows:

Method	Girth in inches	
	November 1920	January 1924
In dynamited holes	20.43	37.80
In hand-dug holes	30.26	40.17

No advantage has been noticed from the plants planted in dynamited holes. The cost of dynamiting holes was more than for holes dug by hands and therefore it is not recommeded especially where labor is cheap.

Density.—The question of whether wide or close planting is best is still a disputed one. Some space the plants 20 by 20 feet apart or even a greater distance; others 6 by 6, 9 by 9, 12 by 12 feet apart or even closer, while others use the avenue sytems of planting 9 by 18, 16 by 18, 12 by 20, 12 by 24, 24 by 30 feet apart and so on for seedlings. For the budded plants 18 by 18 feet is good but 24 by 24 is considered best.

In the Netherlands East Indies 150 to 200 for budded trees and 300 with selected seeds to the acre is the rule. This rule has been evolved by considering the location, soil, rainfall, etc. In Java there is a plantation that originally was planted 250 trees to the acre and since has been thinned out by yield selection after 18 years to 50 trees, but this is considered too excessive thinning. In the Federated Malay States, owing to the present knowledge of variation in yield, it is considered profitable to plant 200 trees per acre and thin out at an early stage by selective thinning to a final stand of 40 to 60 trees per acre, while in Sumatra trees planted 350 per acre were thinned first when 3½ years-old and when ready to tap only 80 to 85 trees per acre were allowed to develop. Of budded trees 150 were originally planted per acre.

In Sumatra estates 1 and 2 dense planting has been tried with the following results:

1. The original trees per acre were as follows:

Block	Number of trees per acre	Distance
A	417	9.5 x11 feet in row.
B	349	10.4 x 12 feet in row.
C	253	12.3 x 14 feet in row.
D	199	13.7 x 16 feet in row.
E	126	17.3 x 20 feet in row.

2. At the end of 3 years no retardation of growth was observed from the different densities as indicated by the average girths at 4½ feet for all blocks as follows: A—23.2 cms., B—22.8 cms., C—24.8 cms., D—23.2 cms., and E—25.2 cms.

3. During the third and fourth year all plots except the D and E were given a preliminary thinning by removing all the smaller trees, which reduced the densities to:

Block		First thinning	Second thinning
A	±	320	200
B	±	275	175
C	±	210	150
D	±	....	125

4. The trial tapping method of thinning proved that a comparative yield could be obtained from trees 3½ years old and that no extra cost was incurred for the trial tapping, since enough rubber was produced to meet the expense.

5. Retardation of growth occurred in all densely planted plots during the 3rd and 4th years as indicated by the average girth increases, viz., A—9.4 cms., B—9.5 cms., C—10.8 cms., D—10.6 cms., and E—12.4 cms.

6. Methods of thinning used:

a. Complete removal.
b. Stumped only.
c. Stumped or ringed.

Stumping cost slightly more than one-half of the complete cost of removal of the trees. After 7 months the plants were sprouting vigorously.

7. Correlation from trial tapping 3½ years old.

Girth and yield	0.518 ± 0.018
Latex vessels and yield	0.347 ± 0.020
Girth and Latex vessels	0.466 ± 0.018
3½ years 6 inches above the ground and 4 years 35 inches	0.675 ± 0.010

8. Costs of thinning are as follows:

First thinning	₱0.048
Second thinning	0.064
Trial tapping and thinning 3-¾-year seedling	0.032
Difference between complete removal and stumping	0.024
Examination of latex vessels	0.024

Estate 2.—Experiments to determine the difference in yield and rubber content on areas planted at different densities have been conducted on this estate with the following results.

Experiment 1.—Difference in yield on areas planted 150 and 75 trees per acre. The yields for two years are as follows:

Block	75 trees per acre		150 trees per acre	
	Pounds per acre	Grams per tree	Pounds per acre	Grams per tree
Average for 2 years	10.9	4.2	22.2	3.4
Average before thinning 16 months	9.0	3.8	19.2	3.4
Average after thinning 8 months	14.5	4.8	28.0	4.8

Experiment 2.—A comparison of 4 different densities—69, 100, 120, and 130 trees per acre. The 69 and 130 classes were not changed but the 100 and 120 classes were thinned from 130 to their present status. An average of the yield for 5 months

before thinning was recorded and compared to 8 months average since thinning and gave the following result:

	Before thinning				After thinning			
Number of trees per acre	69	100	120	130	69	100	120	130
Grams per tree per day	4.4	4.2	4.2	4.7	4.8	4.9	5.0	5.0
Pounds per acre per month	12.0	26.0	26.7	28.4	14.9	25.4	29.4	29.5
Difference after thinning in grams per tree per day	......	......	......	......	0.4	0.7	0.8	0.3
Difference after thinning in pounds per acre per month	......	0.6	......	......	2.9	......	2.7	1.1

It has been noted in this experiment that a heavy thinning at 6 years old is not advisable but that a light thinning is beneficial.

Experiment 3.—To determine the rubber content of 69 and 130 trees per acre. The six months' results are as follows:

69 trees per acre	31.6
130 trees per acre	31.1

In Ceylon at the Henaratgoda Garden a distance of planting was made from April 7, 1922 to 1925, and gave the following results:

Distance	Trees per acre	Total yield in pounds		Remark
		Per tree	Per acre	
1. Clumps of 4 trees 12 x 15 feet with between clump	69	14	1,106	Greatly sloping land.
2. Avenues, trees 15 x 12 feet with 40 feet between avenues	112	9.93	1,080	Flat land.
3. Square 20 x 20 feet	109	12.06	1,284	Fairly steep and rocky land.

Although the above blocks were not well comparable, yet block 1 was, however, rather remarkable and up to the end of 1924 the yield per acre was only 4 pounds behind 2 and is now ahead. The trees on the flat land have given the lowest yield per tree and that wider spacing gave greater increase in girth growth.

New system of planting.—Budded plants from selected mother trees and selected seedlings have been set out alternately in rows at 300 trees to the acre. This is done as follows: A solid row of budded plants is set out and next a row of selected seedlings and so on. This system of planting will insure the plantations having good yielding trees, it is said. The eventual thinning begins when the trees are about 3 to 3½ years old. If none of the budded plants develop into an undesirable tree the removal of most of the selected seedlings will be resorted to, but if one or more of them become undesirable the adjacent seedlings will be retained.

The majority of the planters are, however, in favor of close planting since it affords more material to select from thinning time, especially when affected by disease. The density of the stand at 10 years of age will probably be about 100 trees per acre. To overcome this a new system of planting has been inaugurated which method is at present considered the best, i. e., to plant in alternate rows budded plants and seedlings from selected seeds, as described in the previous paragraph.

Replanting.—Replanting has been found impracticable after the trees were about 3 or 4 years old and on old trees, it is manifestly essential in replanting to reduce the old trees to below 20 per acre if replanting is not performed at the proper time. An experiment undertaken in Sumatra to find out about this gave the following results:

Block	Average number of old trees left per acre	Total area (acre)	Yield per tree in pounds of dry rubber			
			1922	1923	1924	1925
A	9	80	12.2	9.9	12.9	15.3
B	16	20	14.2	17.4	15.2	12.4
C	2½	75	9.6	8.8	13.5	18.7
D	55	10	....	4.8	7.4	7.0
E	11½	10	....	8.5	11.7	12.1

The growth of the young trees continued to be satisfactory except in Block E where only a few developed into normal trees owing to the suppressing effect of the older tree.

Pruning.—Only done when the trees were very close to give more light. All branches about 8 feet from the ground were pruned. Generally pruning has not been considered desirable throughout unless done only to cut out diseased, dead and low hanging branches which interfere with proper supervision and keep the lower portion of the stems too dark. However, early pruning to give a proper shape to the trees has been considered essential. Regular pruning was practiced in one of the largest estates in Sumatra with the main object of producing a well balanced crown. In the same estate experimental pruning of budded plants has been carried on and has given the following results:

	Number of trees	Total girth (cm.)	Average girth (cm.)	Per cent of the control	Per cent of girth increase since previous year
December, 1923—2½ years old:					
1. Control	22	443.9	19.18	100	
2. Pruned heavily	20	369.8	17.49	91.2	....
3. Pruned lightly	21	394.2	17.77	92.7	....
December, 1924—3½ years old:					
1. Control	21	716.5	34.12	100.0	77
2. Pruned heavily	20	621.0	31.05	91.0	77
3. Pruned lightly	21	676.9	32.23	94.4	81
December, 1925—4½ years old:					
1. Control	19	884.7	46.56	100	36
2. Pruned heavily	20	851.0	42.55	91.4	37
3. Pruned lightly	21	926.1	44.10	94.7	36

The trees were all offspring of a clone that had a very good crown development and branching system. For this reason the practical differences between the pruned trees and the unpruned trees are not so strikingly in favor of the former.

The wounds left after pruning were treated either with tar or red lead paint. In the Federated Malay States a proprietory article named "Ubat Getah Luha" has been prepared and put on the market that is said to hasten the callusing of the wounds. A mixture of clay, cow-dung and sulphur is commonly employed especially by the Chinese planters for newly tapped areas.

Cultivation.—Cultivation includes weeding by hoeing and by plowing, cultivator, harrowing, etc. Clean weeding is practiced particularly in all the estates of Java, Sumatra, and Malaya. Weeding will take one laborer per acre a day or 27 acres per month for young rubber and much less for old ones. Clean weeding is not much favored by some of the Malayan planters unless cover crops are planted at once, but instead they allow natural vegetation to grow, except cogon, and this is only cut once in a while. It has been found, however, that clean weeded estates were more flourishing than uncleaned estates.

Hoeing with a native hoe, or changkolling, as it is called, has given beneficial results in certain areas, but control experimental data can not be quoted to show any positive results for rubber that was in bearing in the Federated Malay States. Tillage has not been practiced to any extent and indeed systematic cultivation becomes impracticable after the trees are three or four years old. Experiments in Sumatra show that cultivation by forking, plowing, etc., have resulted in little or no effect on growth or yield of rubber. These are detailed below:

Method of cultivation employed:

1. By forking the whole area 9 inches deep.
    - *a.* Native forks.
    - *b.* The four-pronged European digging forks.
2. By changkolling the whole area 12 inches deep, leaving circles with a 5 feet radius round each tree.
3. and 4. Similar to 1 and 2, respectively, with the exception that alternate rows only were cultivated.

The table below shows the yields for 27 months relative to control of 100 per cent:

Treatment	Kind of soil			
	Red hill soil 1911 planting	White sandy loam 1911 planting	White cementing soil 1910 to 1911 planting	Brown loam 1912 planting
Forked whole area	101	100	Not possible	95
Forked alternate rows	100	96	.....do.....	100
Changkolled whole area	100	99	97	96
Changkolled alternate rows	99	98	99	93

A decrease in yield in practically all soil due to cultivation has been noted. In this estate, it has been observed that annual cultivation was also harmful to the growth of the tree, and that the uncultivated plots made 7.7 per cent better diameter growth in 3 years than the cultivated ones. Best results of root development were obtained in the forked area where less destruction occurred.

To determine the effect in yield of changkolling old rubber trees at the H. A. P. M. in Sumatra, 46 acres were changkolled in May, June, and July, 1921, at a cost of about ₱35.376 per acre. The average figures for one year before changkolling were taken on the two areas. These were compared with the average figures since changkolling as follows:

BLOCK I.—*Matured trees*

	Grams per tree per day	
	Changkolled	Not changkolled
Before changkolling	9.66	8.58
Four months after changkolling	10.95	9.50
Increase	1.29	0.92

Block II.—*Matured trees*

Treatment	Dry rubber in lbs. per plot of 8–⅓ acres				
	1918 6 months	1919	1920	1921 6 months	Total
1. Changkolled entire area	665	1,912	1,959	449	4,985
2. Changkolled alternate rows, *Mimosa* planted October 1919, *Mimosa* changkolled under in January 1921	700	1,926	1,948	500	5,074
3. Control	666	1,979	2,148	495	5,288

Cultivation of young trees has been tried and gave the following results:

Block III.—*Young trees*

Treatment	Average girth inches	
	1920	1921
Cultivated trees	10.99	14.25
Uncultivated trees	11.31	15.07
Difference in favor of the control	0.32	0.82

Thinning.—There is a great variation between the yields of rubber from different trees. They begin thinning when the trees are 6, 7, 8, and 9 years old.

Overcrowded, poorly developed, poor yielding, disease infected plantations were found here and there in the rubber growing countries. If these plantations should remain in this state they will never give as high yields as those in some of the estates where selective thinning is performed. Besides the bark renewal becomes worse each succeeding year. Thinning by selection has been resorted to, which has ultimately reduced the cost price of raw rubber because of the increased production. In thinning first all weak looking plants, diseased trees, trees with a small number of latex rings and poor yielders were removed. All good yielding trees were marked previous to thinning. Thinning out should be done during the dry season if possible in order to prevent the spread of disease. Thinning has been demonstrated by various experiments.

The yields obtained by selective thinning from the various estates are as follows:

In Java.—*Trees planted in 1909*

Plot	1	2	3	4
Tree to the acre	136	136	136	136
Six months' yield	100	96	97	99
Thinned to	136	120	104	96
Six months' yield	100	106	103	100

In the same experiment estates planted with 180, 160, 140, and 120 trees to the acre produced 46, 49, 51, and 56 kilograms of rubber, respectively: Plots with 120, 110, and 100 trees to the acre produced 57, 78, and 84. From 131 trees thinned to 111 trees per acre the production increased from 313 to 333 pounds per acre. In all cases more yields with fewer trees. It has been observed also that with 185 trees to the acre the yield went down in the 6th year and with 90 trees in the 9th year.

IN JAVA.—*Thinning from 1,673 to 1,010 trees*

Class	Daily production (cc)	Number of trees removed	Number of trees remained
0	0	201	44
1	0—10	350	308
2	10—20	88	319
3	20—40	22	256
4	40—60	2	65
5	> 60	0	18

From this experiment it has also been noticed that the bark renewal was best in thinned plots and that there was less striped canker, as indicated below:

Bark renewal on:	Mm.
104 trees to the acre	4.01
80 trees to the acre	4.24
63 trees to the acre	4.31
Striped canker on:	Cases
104 trees to the acre	82
80 trees to the acre	50
63 trees to the acre	27

In Sumatra the following results were obtained:

Experiment I

Classes	Before thinning				After thinning			
	69	100	120	130	69	100	120	130
Grams per tree per day	4.4	4.2	4.2	4.7	4.8	4.9	5.0	5.0
Pounds per acre per month	12.0	26.0	26.7	28.4	14.9	25.4	29.4	29.5

As to the rubber content, 69 and 130 trees to the acre gave 31.6 and 31.1 per cent rubber content, respectively. The 69 and 130 were not changed, but the 100 and 120 were thinned from 130 to their present numbers in March 1921. An average of the yield for 5 months before thinning was made and compared to 8 months average since thinning.

Heavy thinning in the sixth year was found inadvisable but light thinning was found beneficial.

From thinnings done in Experiment 1 in Sumatra, it has been found that reducing to less than 80 trees per acre is not desirable either on the red or white soil.

On good red soil for trees 10 years old 65 trees are too few per acre. The best number is probably between 80 and 90 trees per acre.

The results by ultimate thinning of the plantations to 82, 71, and 63 trees per acre, respectively, are as follows on white soil:

Experiment II

Year	Pounds of dry rubber per acre			Per cent relationship		
	Series 1	Series 2	Series 3	Series 1	Series 2	Series 3
1918—6 months	104	94	99	100	90	95
1919	273	253	273	100	93	100
1920	315	301	313	100	95	99
1921	215	125	214	100	95	99
1922	292	303	288	100	104	99
1923	266	277	258	100	104	97
1924	355	336	322	100	95	91
1925	407	381	363	100	94	89
Total	2,227	2,160	2,130	100	97	96

Series 1.—Control, 83 acres with 121 trees per acre. At the end of 1922 had 112 trees per acre. In March 1923, all poor trees were removed leaving only 82 trees per acre.

Series 2.—Eighty-three acres originally thinned to 80 trees per acre by yield selection. Poor trees removed September 1922, leaving 71 trees per acre.

Series 3.—Eighty-two acres pruned originally to 80 trees per acre. Most of the pruned trees were later taken out in the removal of the poor trees in September 1922, and again thinned in January 1923, leaving 63 trees per acre.

The results by thinning the plantations to 91 and 65 trees per acre on red soil were as follows:

Experiment III

Year	Pounds 1st latex dry rubber per acre		Per cent relationship	
	Non-thinned	Thinned	Non-thinned	Thinned
1922—2 months	82.3	71.7	100	87
1923	525.0	458.9	100	87
1924	609.7	528.5	100	87
1925	618.4	528.6	100	85.5
Total	1,835.4	1,587.8	100	86.4

Series 1.—Ninety-three acres and only useless trees removed and now has 91 trees per acre.

Series 2.—Ninety-two acres were thinned to 65 trees per acre. In thinning series two, the poor yielding trees were not removed so that the remaining trees are evenly distributed over the area. This thinning was done during July, August, and September, 1922.

The table below shows the 1925 yield after thinning and replanting had been done.

Experiment IV

Plot	Trees per acre		Total of 4 tapping months	
	May	December	Per acre	Per tree
1—A	200–199	126	271	1.7
1—B	175–174	119	260	1.89
1—C	150–148	124	256	2.00
1—D	123	123	245	2.00
1—E	116	116	197	[a]1.70
2—A	200	200	250	[a]1.25
2—B	174	174	194	1.11
2—C	154	154	219	1.42
2—D	122	122	172	1.41
2—E	110	110	204	[a]1.86
3—A	199	199	267	1.34
3—B	175	174	253	1.46
3—C	150	150	198	1.32
3—D	123	123	137	1.12
3—E	110	110	139	[a]1.27
4—A	315	282	213	.74
4—B	275	254	192	.75
4—C	209–206	186	180	.95
4—D	190	190	169	.90
4—E	125	125	123	1.00

[a] Stands for control.

It indicates no increases in yield except in one block.

It is quite obvious that 175 or more trees per acre when trees are 5 to 6 years old, result in a decided suppression, such that the yields despite the previous selection of the better trees are only slightly better per tree than in the control (E) plots and the gain in yield per month is much slower.

Experiment V.—Systematically removing every third row and alternate row in the latter case.

Treatment	Dry rubber in pounds						Total
	1916	1917	1918	1919	1920	1921 3 months	
Control	1.202	1,277	1,666	1,819	1,693	304	8,001
Thinned to 80	740	771	1,014	1,393	1,250	232	5,409
Thinned to 60	605	660	909	1,292	1,175	202	4,843

Treatment	Dry rubber in pounds						Total
	1916	1917	1918	1919	1920	1921 3 months	
Control			[a]8,669	22,716	26,125	17,889	75,399
Thinned to 80			7,745	21,000	24,987	17,865	71,597
Thinned to 60			8,094	22,360	25,661	17,546	73,661
1. To 90 trees February, 1917 To 60 trees October, 1918		[b]1,174	1,501	1,845	1,618	[c]277	6,415
2. To 60 trees February, 1917		1,051	1,361	1,841	1,493	289	6,035
3. Restocking July, 1919		1,085	1,290	1,441	1,117	220	5,153
4. To 30 trees February, 1917		1,068	1,310	1,602	1,378	265	5,623
5. Restocking July, 1919		1,163	1,448	1,665	1,298	262	5,836
6. To 90 trees February, 1917 To 80 trees October, 1918		1,144	1,462	1,899	1,783	343	6,631
7. To 60 trees February, 1917		942	1,208	1,740	1,588	293	5,771
8. Restocking July, 1919		1,067	1,298	1,629	1,389	261	5,644
9. Restocking July, 1919		1,056	1,309	1,624	1,523	257	5,769
10. Control		1,234	1,621	1,915	1,682	301	6,753

[a] 6 months. [b] 9 months. [c] 2 months.

In one of the estates in Ceylon where thinning from 161 to 106 trees per acre of 20-year old trees was done the production remained at 439 pounds per acre.

Before thinning the individual tree yield is being observed for at least two weeks.

Manuring.—Most Malayan rubber estates were located in virgin forest land and no fertilizer is needed for a long time if the surface soil is preserved. It is believed that in other plantations where rubber has succeeded other crops such as coffee, gambier, pepper, pineapple, sugar cane, cassava, etc., the soil is partly exhausted. And fertilization of this kind of soil has recently been started, but so far no definite conclusion has been drawn, although they say that the fertilized area responds encouragingly to nitrogenous manures.

In Sumatra and Ceylon manuring has been tried, and the results are given below. The factors considered in fertilizing rubber are the size and number of plots, variations in the soil, tapping system and quality of tapping, uniformity in growth, distance of planting and variation of the individual yield of trees and to reduce the possible errors to the minimum.

With regard to the manuring in Sumatra it has been found that white clay soils responded well to the treatment, but that the red soils did not. These white clay soils of Sumatra contain very little humus and nitrogen—obviously the limiting factors. Nitrogenous fertilizers were applied and there was a prompt response. On the other hand on the red soil manuring had hardly any effect, as indicated below.

Experiment 1.—Artificial fertilizers were applied in various mixtures beginning in October, 1918, and discontinued, in February, 1921 at the H. A. P. M. The final percentage yields are as follows:

Block	Treatment per acre in pounds	Red soil	Brownish loam	White clay (cement)	Loam
A	Nitrate of Soda 300 Potassium chloride 150 Basic Slag 300	99.3	104.8	102.3	115.9
B	Nitrate of Soda 300 Potassium chloride 150	91.7	107.5	106.5	116.2
C	Control	100.0	100.0	100.0	100.0
D	Nitrate of Soda 300 Basic Slag 300	99.1	100.6	109.6	103.3
E	Basic Slag 300 Potassium chloride 150	99.4	93.8	104.4	97.5
F	Lime 2,000	95.7	92.6	95.6	103.8
G	Lime 2,000 Nitrate of Soda 300 Potassium chloride 150 Basic Slag 300	91.3	100.7	101.0	105.3
H	Control	100.0	100.0	100.0	100.0
I	Mimosa planted January, 1919 and changkolled March, 1920	....	99.8	105.7	99.9

The fertilizers were broadcasted and hoed lightly. The nitrate fertilizers gave striking results on white soil in all respects as to yield, bark renewal, foliage, and general appearance, and since the nitrate was not applied during the wintering period the maximum effect was not obtained. On red soil a favorable result was obtained in one case, while the potassium and phosphate fertilizers were without effect in both soils. The superphosphate was actually harmful owing to its acidity. *Mimosa invisa* had no effect on white soil. The deterioration in appearance of the control trees continued and die-back was excessive.

In every case manuring the plots with nitrates gave an increased yield and accelerated the formation of the number of latex vessel rings of the plants, while the superphosphate exercised a pronounced depressing effect both in yield and growth from which the subsequent calcium nitrate application partially relieved it.

Experiment 2.—The following fertilizers and quantities were also tried and the results are tabulated below:

A—Control, untreated.
B—5 hundredweight nitrate of soda per A applied February 1919.
  5 pounds Ammo-phos per tree applied March 1924.
C—3 hundredweight nitrate of soda per A applied February 1919.
  5 hundredweight nitrate of soda per A applied February 1920.
  5 hundredweight nitrate of soda per A applied March 1921.
  5 hundredweight nitrate of soda per A applied February 1922.
  5 pounds nitrate of soda per tree applied February 1923.
  5 pounds nitrate of soda per tree applied March 1924.
  5 pounds nitrate of soda per tree applied February 1925.

D—1 hundredweight nitrate of soda per A applied February 1919.
5 hundredweight superphoshate per A applied April 1920.
5 hundredweight calcium nitrate per A applied March 1921.
5 pounds calcium nitrate per tree applied February 1923.
5 pounds ammonium sulphate per tree applied February 1925.
E—5 hundredweight ammonium sulphate per A applied March 1920.
5 hundredweight ammonium sulphate per A applied March 1922.
4 pounds ammonium sulphate per tree applied February 1924.

EXPERIMENT 2.—*Results on 11-year old rubber seedlings*

Year	Yield in pounds per acre of dry rubber first latex and lump					Per cent relationship				
	A	B	C	D	E	A	B	C	D	E
March 1919—February 1920	278.9	339.6	320.8	301.9	292.1	100	122	115	108	105
March 1920—February 1921	310.5	397.8	392.8	325.3	353.3	100	128	127	105	114
March 1921—February 1922	180.4	280.9	353.8	237.1	283.0	100	156	196	131	157
March 1922—February 1923	298.0	400.9	533.5	381.7	464.7	100	135	179	128	156
March 1923—February 1924	171.2	256.6	421.8	251.4	352.5	100	150	246	147	206
March 1924—February 1925	255.4	346.3	535.3	368.5	466.5	100	136	210	144	182
March 1925—December 1925 (10 months)	224.0	297.3	462.0	325.1	395.2	100	133	206	145	176
Total	1,718.4	2,319.4	3,020.0	2,191.0	2,607.3	100	135	176	127	152

The yields of the C plot manured annually and the E plot manured once in two years were the highest in the history of the experiment. The control plot continued to deteriorate in appearance and the condition of many of the surviving trees was serious owing to the extensive die-back.

Experiment 3.—The effect of nitrate on the yield of rubber planted during the latter part of 1911 on white soil, and fertilized February 1918, at the rate of 5 hundredweights per acre is as follows:

EXPERIMENT 3.—*Results for 3 years and 10 months*

Fertilizer	Yield of latex in pounds per tree
Sodium nitrate	26.504
Control	20.114
Sodium nitrate	25.497
Control	23.568
Sodium nitrate	26,429
Control	22.244

The sodium nitrate has increased the yield about 15 per cent besides improving the foliage. Furthermore, the average bark thickness and the formation of latex vessels were more in the fertilized trees.

Further experiments with nitrate of soda have been performed and gave the following results from March 1919, to February 1924, on white soil.

YIELD FROM MARCH 1919, TO FEBRUARY 1920

Plot	Fertilizer per acre or per tree	Per acre (in pounds)	Per cent relationship
A	Control	279	100
B	5 hundredweight nitrate of soda	340	121.7
C	3 hundredweight nitrate of soda	321	115
D	1 hundredweight nitrate of soda	302	108.2
E	Control	292	104.7

FROM MARCH 1920, TO FEBRUARY 1921

A	Control	310	100
B	Not manured	398	128.1
C	5 hundredweight nitrate of soda—February 1920	393	126.5
D	5 hundredweight superphosphate—April 1920	325	104.8
E	5 hundredweight ammonium sulphate—March 1920	353	113.8

FROM MARCH 1921, TO FEBRUARY 1922

A	Control	180	100
B	None	281	155.7
C	5 hundredweight nitrate of soda—March 1921	354	354
D	Calcium nitrate—March 1921	237	237
E	None	283	283

FROM MARCH 1922, TO FEBRUARY 1923

A	Control	298	100
B	None	401	134.6
C	5 hundredweight nitrate of soda	533	179
D	None	382	128.1
E	5 hundredweight ammonium sulphate	465	155.9

FROM MARCH 1923, TO FEBRUARY 1924

A	Control	171	100
B	None	257	149.9
C	5 pounds nitrate of soda—February 1923	422	246.8
D	5 pounds calcium nitrate—February 1923	251	146.8
E	None	352	205.9

MARCH 1924

A	Control	85	100
B	None		
C	5 pounds nitrate of soda	312	367
D	4 pounds ammonium sulphate		
E	None	245	288

In February 1919–1920, the nitrate was apparent in the color of the foliage especially in 5 and 3 hundredweight March 1920, to February 1921. The C plots maintained the better color of the leaves and the B were better than the A, but inferior to the C. The E showed the same as C while the D were slightly superior to the A because of the previous application of nitrate. From March 1921, to February 1922, the D gave immediate results in the color of the leaves, and the B were still better than the A. The C were very striking in appearance with no die-back and with excellent bark renewal. From March 1922, to February 1923, the C continued to improve in appearance and the B deteriorated. The E were equal to the C while the D maintained a fairly good appearance. From March 1923, to February 1924, the C in appearance were the best and identical with those in red soil; and the E were practically the same as before while the D were inferior but still excellent. The B were deteriorating.

In March 1924, the renewal of bark was 139.4 per cent on the C plots, 126.3 per cent on E, 116 per cent on B, 110.2 on D based upon the 100 per cent of the control plot A. The percentage relation of the bark thickness was 100 for A (control), 107.2 per cent for B, 116 per cent for C, 107.2 per cent for D, and 113.8 for E, and their corresponding girths were 100, 102.7, 111.6, and 110.9, respectively.

Experiment 4.—Manuring with ammo-phos at the rate of 5 pounds per tree gave 1,507.6 pounds of latex from March 1924, to December 1925, as against 1,540.9 for the unmanured plot. The percentage relationship then was only 98 compared with the 100 in the unmanured plot. It is therefore definitely settled that ammo-phos not only has no advantage over the ammonium sulphate, but was not productive of any result. Ammonium sulphate and nitrate of soda were the two best and of these the former was a little better because less subject to loss by leaching.

Experiment 5.—Manuring with different amounts of ammonium sulphate gave the following results:

Plots	Amount in pounds per tree	Yield per acre in pounds			Total yield of latex	
		1923	1924	Total	354 trees	356 trees
					Pound	*Pound*
Fertilized	4	620.7	1,018.1	1,638.8		
Control		516.8	793.7	1,310.5		
Fertilized	5		623.7			
Control			627.0			
Fertilized	5				20,613	
Control						17,723

In the first set of experiments the yield of the fertilized plot was increased 25 per cent over the control and the effect of the ammonium sulphate was apparent on all plots. On the second trial the ammonium sulphate gave no extra yield. A very slight effect on the color was noted about 2 months after the application. An increase of 16 per cent of the fertilized plot over the control was recorded from the third test. A gain of 2,890 pounds latex and with an average of 39 per cent dry rubber content, this will equal 1,127 pounds of dry rubber, which represents the gain in 2 years at a cost of ₱152.00 for ammonium sulphate.

The best time and method for the application of nitrogenous manures are a month or two before wintering or during the wintering period. Nitrates are readily washed out and, therefore, cannot economically be applied long beforehand. Ammonium sulphate is less easily leached and has been applied at fortnightly intervals from the beginning of December to the end of January in Sumatra. They should be broadcasted after the removal of weeds and green manures in flat land and on hilly areas applied in shallow ditches along the contours. In cleaned rings around the trees 1.5 to 2 meters radius, the drawback is that the roots take up much manure and therefore the assimilation will be much slower and less complete. If the distance is 7 by 7 meters the rings (the width being 1 meter and the increase in radius 1.5 to 2 meters) will occupy only $\frac{1}{3}$ to $\frac{1}{4}$ of the total surface. Applying every other year was found economical.

Experiment 6.—Manuring young trees with *Vigna oligosperma* on March 1924, to November 1925:

Fertilizer and rate per tree (pounds)	Yield of dry rubber per acre in pounds	
	Yield	Per cent
1. Clean weeded	665.7	100
2. Clean weeded, 5 pounds $NaNO_3$ and *Vigna* replanted May 1924	639.2	96
3. *Vigna* only	619.4	93
4. *Vigna* with 5 pounds $NaNO_3$	648.7	97
5. *Vigna* with 4 pounds Ammonium sulphate	653.3	98

On the rubber plantations of Ceylon which in general were started longer ago than those in the Federated Malay States or Sumatra and moreover where the soil was rather poorer than that of Sumatra and Federated Malay States manuring has been practiced for some years. Cattle, green and artificial manures have all been used at an average rate of 600 pounds per acre or from 1 to 7 pounds per tree, and applied before wintering in many of the estates by either broadcasting or in trenches; but no yield records have been kept by the planters.

In Ceylon, soil at the Peradeniya Experimental Station organic and inorganic fertilizers applied annually from February and April 1913, respectively, except in 1914—broadcasted in trenches 3 by ½ feet and 2 by 3 feet dug between the rows of trees and forked together with dead leaves afterwards gave the following results:

EXPERIMENT I.—*Results from 1914–1923*

Blocks	Fertilizer	Rate of application in pounds				Amount of—		Total yield of dry rubber (1914—1923) per tree in pounds	Cost of application per acre for 3 years
		1913	1915	1916	1923	First aplication	Second application		(₱)
1	Groundnut cake	300	156	200		56.5 N	50 N		
	Fish guano	150	110						
	Blood meal	100	60	200		34 P_2O_5	30 P_2O_5		
	Steamed bone dust	100	52	136					
	Sulphate of amm.	40	39	60		87 K	30 K		
	Nitrate of potash	150							
	Muriate of potash		104						
	Sulphate of potash			75				41.18	136.76
2	Groundnut cake	300	95	182					
	Fish guano	200	100			74.3 N	80 N		
	Blood meal	150	140						
	Steamed bone dust	20		300		20.4 P_2O_5	9.5 P_2O_5		
	Sulphate of amm.	90	120	150		46.4 K			
	Muriate of potash	80							
	Sulphate of potash		15					42.81	149.62
3	Groundnut cake	150	56	50	136				
	Fish guano	200	112			32.5 N	9.5 N		
	Steamed bone dust	200	111.51	200					
	Muriate of potash	100				98 P_2O_5	80 P_2O_5		
	Basic slag	190	112	200		58 K			
	Sulphate of potash		16		200			43.56	55.14
4	Control							40.8	
5	Groundnut cake	200	114	136	50				
	Fish guano	100	114			32.5 N	9.5 N		
	Blood meal	160				30 P_2O_5	80 K		
	Steamed bone dust	100			200				
	Muriate of potash	150	90			114.6 K			
	Kainit	230	110						
	Sulphate of potash			200					
	Basic slag				200			33.87	57.75
6	Nitrolim	320	190	278		57.6 N	50 N		
	Basic slag	170	100	176		34 P_2O_5	30 P_2O_5		
	Sulphate of potash	174	102	75		87 K	30 K	36.62	111.61

From 1917 to 1922, inclusive, the annual application in Blocks 3 and 5 remained the same as in 1916 except in the inorganic mixture in Block 6, in which no further application has been made since 1917. The same quantities from 1916 to 1923 were applied annually in Blocks 1 and 2.

The highest yield during the whole period of the experiment has been recorded from the excess of phosphoric acid plot although the development of foliage and general vigor was less than in any of the other plots.

EXPERIMENT II.—*Results from 1922–1923*

Blocks	Treatment	Quantity per Acre	Total yield per tree
		Pounds	*Pounds*
1	Control-Lime	896	5.25
2	Superphosphate	138	
	Basic slag	147	
	Sulphate of potash	120	
	Lime	896	4.62
3	Nitrolim	277	
	Sulphate of potash	120	
	Lime	896	4.87
4	Nitrolim	277	
	Superphosphate	138	
	Basic slag	147	
	Lime	896	4.12
5	Same as 2 but without lime		4.75
6	Same as 3 but without lime		4.31
7	Same as 4 but without lime		4.00

The results of the annual experiments in Ceylon clearly indicate that manuring has not increased the yields enough to more than pay the cost of application, but has benefited the foliage and hastened bark renewal, or afforded disease immunity.

DISEASES AND PESTS

All planters endeavor to prevent the introduction of new diseases and pests and take measures to eradicate any existing ones. A regular inspection and sanitation system which includes the removal of all infected trees immediately is practiced. Expenditures for pest and disease work and especially for preventive treatment is regarded as a form of insurance, the annual premium on which after all, amounts to but a very small percentage of the capital value, they say. The present existing pests and diseases found in one country are also common in others especially the most important ones. These diseases are divided into root, stem, leaf, and pod diseases. Among the important ones are the following:

Root disaases.—*Fomes* is probably the most important. In one of the estates in Sumatra in 1921 alone 90,421 trees were up-rooted because of *fomes.* Its occurrences depend upon jungle stumps which have not been uprooted and on poorly drained land and soil acidity at the time of clearing. The most losses occur in 2 to 4 year old trees. A comparison of the trees infected with *fomes* in changkolled and unchangkolled land gave the following:

	Per cent infected
In changkolled land only	1.6
In unchangkolled land	10.7
In unchangkolled land	11.5
In unchangkolled land	9.9
In unchangkolled land	9.3

Unless a considerable sum of money is spent in careful examination and diagnosis, cases of the wet-rot *Fomes pseudoferreus* cannot be determined in the earlier stages, and when the disease has traveled along one or more lateral roots until the tap-root and bole are involved the tree is usually beyond recovery, and the sooner it is removed the better. In advanced stages the disease can be recognized by the dying of stems. In one of the estates in Sumatra this disease has killed about 50 per cent of the trees in small blocks and on an average of about 20 to 25 per cent in the whole estate.

F. lignosus has also been found on old trees, though formerly it was claimed that it attacked only young ones. On a certain type of soil it is so widely spread in Malaya, Sumatra and Ceylon that control is almost impossible and very likely it may become a limiting factor for rubber production.

No definite control measures have so far been found for root diseases, except the removal and burning of the badly affected trees. The slightly affected roots are cut off up the sound ones. The spread of the disease can be controlled by isolating diseased trees. This is done by digging trenches between them and the healthy ones. Liming, good drainage, aërating the infected area and constant inspection have been found beneficial. In Java a mixture of coal tar and lime in equal proportion has been tried with success. In one of the estates in Sumatra there were 57,377 trees affected with *fomes* in 1922 and 30,046 in 1923.

Sun scorch caused by the exposure of the lateral roots to the sun, which is very common here and there in Federated Malay States, Ceylon, Java, and Sumatra because of soil-wash, has caused the cracking and drying of the bark besides the die-back of branches. Over-cropping, terracing or banding the soil may eliminate this physiological trouble.

The red-root disease, *Ganoderma ferreus,* is controlled in the same way as *fomes,* and also the brown-rot disease, *Hymenochaete noxia. Sphaerostilbe repens* has been found dangerous but rarely occurs. It has a black mycelium. Treatment is the same as for *fomes.*

Stem diseases.—These are more or less seasonal and methods of their control are all known for all. The stem canker and the bark rot are probably the most common especially during the wet season. The black stripe and the mouldy rot attacking the tapping cut and renewing cortex below 36 inches, are the most common ones. *Ustulina zonata* attacks both stem and branches 20 or more feet in height. It is believed to be the result of neglect after pruning or after a wind has broken off branches or leaving dead wood around the estate. It is considered a very slow working disease so that it only becomes evident when it is too late to save the tree. Found only on older trees, it is characterized by wrinkled bark and black exudations. The treatment consists in cutting off the diseased parts and painting with tar.

Brown bast or back canker, although nowadays no longer considered a specific disease caused by an organism, is discussed under the diseases of bark. However, Mr. Keuchenius believes that this is caused by bacteria but does not consider them to be actively parasitic but as living on the latex, coagulating it and causing irritation on the latex vessels. The disease is spread by the movement of the bacteria in the latex and not by active growth. It is found to attack only older trees, entering either at the base of the tree or at a tapping cut. Trees not brought into tapping are rarely affected. The effect is to kill the bark and dry up the flow of latex and later to cause the death of the entire tree. The first sign is usually a falling off in the yield of latex and a discoloration of the bark on the tapping cut. In its later stages, burrs are formed and the surface of the bark becomes very rough and uneven. If taken in time, the tree may be saved, by deep scraping of the infected bark down to within 1 millimeter from the cambium, making incisions down to the wood around the infected area and by resting the tree afterwards until the bark has begun to grow rapidly. Within three months there is in many cases, 50 to 60 per cent of new bark. If all diseased bark can not be removed at first, it is worked out again towards the outside. This has the same effect as applying tar, while there is not the danger of killing the cambium as there is with tar treatment. Furthermore, it is cheaper as it saves the cost of the tar. Several patent medicines have been tried but have not proved of value. The trees treated with brown bast are rested from 1 to 10 months, depending of course on the extent of the injury. It is reduced by less severe tapping systems with longer intervals between successive tappings.

Stripe or patch canker, Phytophthora faberi is prevalent mostly in poorly drained soil during the rainy season but is not considered a serious disease unless allowed to develop in its advanced stage since when the weather gets drier the disease disappears. The badly affected trees are rested and the tapping cut changed. Furthermore, the affected parts are painted with a mixture of oil and tar in equal proportions. A mixture of alcohol and resin in the proportion of 3 to 1 brushed at the bark has prevented the stripe canker. A decrease of 87 per cent, 81 per cent, and 75 per cent in the treated plots and in the control of only 41 per cent, 24 per cent, and 16 per cent occurs during the same period. The mixture costs 75 centavos per liter as against 88 centavos for izal. Furthermore, izal must be used at least twice as often. On the H. A. P. M. 3 per cent solution of izal has been found sufficient against black-thread if applied daily after tapping. But it may cause burning of the newly tapped surface at this strength. For field use a solution of 1 izal to 1 unslaked lime and 31 water is used. On the Goodyear Plantation a 5 per cent solution was employed.

Pink disease.—A wet weather disease that goes up and down with the season on closely planted areas especially where sun and wind have no free access. But it does little real damage because it can be easily controlled by a systematic inspection of all areas and the proper treatment. The badly affected parts are cut off and burned immediately and the newly diseased trees are treated with 20 per cent izal or tar. Warm the coal tar before applying. The badly affected parts exude latex. In Sumatra on one of the estates, 46,025 trees were attacked by pink disease in 1923 against 4,511 in 1922.

Mouldy rot (*Sphaeronema fimbriatum*).—This is a dangerous disease attacking the tapping surface above two feet from the ground. A little fructification on the tapping surface develops from the fungus. First white it soon shows black above the tapping cut. It is a result of conditions unfavorable to the physiological functions of the tree. Any condition which tends to reduce the water supply of the trees appears to favor its development. Among such factors may be mentioned impervious or very sandy soil, wintering, a high tapping cut, very deep tapping or very hot and dry weather or a combination of some of these factors. The application of nitrate seems to reduce the incidence of mouldy rot. The application of 2 or 3 per cent izal or carbolineum and resting the tree after tends to eliminate the fungus. Usually the tree is not tapped for a month and when tapping is resumed strips of untapped bark equal to one month's consumption are left. The actual lesion is to be scraped and tarred. In more advanced case the resting period is extended and the width of the untapped bark left is made in proportion. The tapping knife has been found to carry and spread the disease so it is better to disinfect the knife with izal or boiled water before using it.

Dry rot has been prominent during dry weather and in poor soil. It was found in tapped bark. The trees were rested and tapping done an inch below the old tapping cut when resumed.

The black-thread has been controlled by staining izal with unslaked lime of about 3 per cent solution. The solution is prepared as follows:

One cup of izal to 1 cup of unslaked lime and 31 cups of water. It affects the little branches and kills the small twigs and leaves. Cut away and burn the affected parts with the mycelium in the bark.

The *white stem blight* which is not a dangerous disease is found in loose bark. Cut and burn the diseased portion.

The *die-back* (*Diplodia theobroma*) has sometimes affected the rubber badly, but is easily controlled by sanitation and the excision of all attacked woods and cortex.

Leaf diseases.—The black thread usually makes its appearance on the leaves and seed pods. *Phytophthora faberi* is of frequent occurrence in Ceylon on rubber leaves and *P. meadii* is also found. *P. faberi* causes a secondary fall of leaf. The leaf mildew (*Ordium sp.*) was found in new foliage and disappeared during dry weather.

An unidentified fungus causing the dropping of leaves during wintering may become serious if conditions exist favoring it. Young leaves are frequently attacked before completely unfolded. The flowers are severely attacked also. Occasionally a second or even third leaf fall takes place.

Helminthosporium heveae.—By killing the mites this disease disappears. This fungus develops after the attack of the mites.

Roetdauw fungus is found on the outside of the leaves. It is black and associated with the trees and mites feeding on the sugary material of the plant.

Phyllosticta heveae occur first on the edges of the leaves in a black fructification but is not dangerous.

Gloeosporium has also been observed on rubber leaves but to a light extent only. About 25 cases have been reported in one of the estates in Sumatra.

Pod diseases.—*P. faberi* occurs also in pods.

The horse-hair blight occurs both on fruit and stem but is not dangerous.

Pests.—There are not so many pests for rubber as for other crops. The white ants (*Termes or Coptotermes gestroi*) and boring beetles are found purely secondary and only attacking the trees weakened by diseases. Mercuric chloride is preferred for white ants and also lime and sulphur. The chief remedy is to remove all dead wood and field jungle. The presence of the wood borer in the tree indicates the presence of some disease, like *fomes* or that it has been struck by lightning. By regular inspection for all diseases this is kept down to a minimum. Picking the beetles by hand is done.

Plant mites cause considerable damage to the growing shoots of young trees. They are controlled by cleaning all jungle and changkolling the land. The *Tarsonemus* mite which sucks off the leaves of young seedlings is killed by dusting with sulphur. The leaves wrinkle and fall when sucked by the insects.

Acanthopsyche snelleni.—This is a small moth the caterpillar of which damages the newly tapped bark. It is kept in check by paste and bands around the stem of the tree.

At the Goodyear Rubber Plantations the average cost of treating diseases and pests was 4.4 centavos in 1919 and in 1920 the average cost of treating 1,311,900 trees was 2.09 centavos a tree. It is said in 1918 alone this company spent ₱13,151.64 for disease treatment because of the neglect of the plantation during the previous years, of which ₱6,614.19 was spent for labor, ₱3,738.60 for European supervision and ₱3,098.85 for instruments and materials.

TAPPING

Half, third and fourth spiral systems of tapping with one cut are commonly employed throughout Sumatra and Java, while in the Federated Malay States and Ceylon the V, one-half or one-third cut over the circumference are still the favorite ones and tapping alternate days. The two V's only were observed in Indo-China. This system compared with the other tapping systems is described in the "Revue de Botanique Appliquée et d'Agriculture Coloniale, Paris." The one "V" is being employed on a few large estates in the Federated Malay States and in Sumatra, but more particularly on the Chinese-owned estates. Tapping is commonly done either on alternate days or in alternate months. Usually they begin tapping on trees 5 to 7 years old or when they reach 20 to 24 inches in girth 3 feet from the ground. The age is not taken as an indication but rather the girth. Tapping in a new block commences when about 50 to 70 per cent of the trees have reached the desired girth 3 feet from the ground. It has been observed that on 5-year old trees, the composition of the latex and rubber differs from that obtained from old trees. Also the correlation of the latex vessels was smaller than normal. Tapping is done in the morning and it should be finished about 9:30 or 10 o'clock, because of the greater transpiration after that early hour, and the latex should be in before 12 to 1 o'clock. Late tapping besides its adverse influence on the afternoon work also affects the production seriously, they say. It has been found out that trees tapped after 9 a. m. give much less rubber than when tapped early in the morning.

As a guide in tapping the bark thickness of the different ages of trees has also been determined as follows at the Goodyear Rubber Plantations:

Age in years	Bark thickness in millimeters		Girth in inches
	One foot high	Three feet high	Three feet high
11	8.7	8.3	41.1
10	8.6	8.2	40.5
8	8.0	7.0	34.1
6	7.0	6.3	20.4
4½	5.2	4.5	18.6
3½	4.7	3.8	14.4
3	3.7	3.0	9.7
2	....	....	4.0

Time of tapping.—The results of the work along this line are as follows:

EXPERIMENTS BY DE JONG IN 1915

6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	12 noon	1 p. m.	2 p. m.	3 p. m.
133	127	....	105	100	111	....	....	....	162
....	....	95	....	100	87	....	....	....	87
24	....	121	....	100	120	....	....	....	....

EXPERIMENT BY LENNEPS IN 1919

100	102	99	94	90	85	....	....	84	87

EXPERIMENT AT THE H. A. P. M. IN 1922

100	104	103	100	93	86	85	....	....	96

Maas of Sumatra says that experimentally both in Java and Sumatra it has been shown that the production in the morning hours was greater than later in the day. Especially after 9 o'clock, the production decreases.

Another experiment conducted at the H. A. P. M. showed that from 6 to 9 a. m. gave a maximum first latex yield. Later than this the percentage of low grade increased rapidly as tabulated below.

Treatment	Number of trees	Yield in pounds			Yield per tree			Per cent elationship (6.a.m. 100%)
		First grade	Lower grades	Total	First grade	Lower grades	Total	
6 a. m. (tapped)......	523	453.09	61.71	514.80	0.867	0.118	0.985	103.0
7 a. m. (tapped).......	512	456.53	64.27	520.80	0.893	0.125	1.018	103.3
8 a. m. (tapped).......	519	451.73	65.49	517.22	0.870	0.126	0.996	101.2
9 a. m. (tapped).......	507	433.18	72.74	505.92	0.855	0.143	0.998	101.3
10 a. m. (tapped).......	523	433.75	76.87	510.62	0.830	0.147	0.977	99.1
11 a. m. (tapped).......	525	411.20	81.14	492.34	0.783	0.154	0.938	95.3
12 a. m. (tapped).......	507	356.10	79.68	435.78	0.703	0.157	0.860	87.3
3 p. m. (tapped)......	508	431.90	74.62	506.52	0.850	0.147	0.998	101.3
4 p. m. (tapped)......	510	391.74	67.94	459.18	0.767	0.133	0.900	91.4

Very little difference was shown in the total yields except at 11, 12 and 4 o'clock. After 8 o'clock, however, there was a decided falling off of first-grade latex yield and a corresponding increase of lower grade. The difference of the 3 and 4 o'clock was due only to the hurrying up of the tappers.

In Malaya a loss of from 25 to 40 per cent was experienced by late tapping. Afternoon tapping gave approximately 60 per cent only of the normal yields. The yield obtained when tapping was done at 2 p. m. never exceeded 50 per cent of a normal day's crop. And with late tapping, the output from any daily system was more adversely affected than in the case of alternate day tapping.

Tapping height.—In well managed estates they tap to not more than 40 inches high, but in some Asiatic-owned plantations the trees are tapped higher than 40 inches and to 20 inches in opening new trees. The yield for sections of bark at different heights in the trees with 1½ inches bark consumption are as follows at the H. A. P. M.:

Height	Yield	Height	Yield	Height	Yield
Inches	*Per cent*	*Inches*	*Per cent*	*Inches*	*Per cent*
0— 6	147	24—30	99	3	100
6—12	138	30—36	93	9	99
12—18	113	36—42	92	15	57
18—24	100	42—46	76	21	56

In Java it has been found that the number of latex vessels and thickness of the bark decreases from the base of the tree upward. There is a decline of 17 to 18 per cent in yield for every foot upwards compared with the yield obtained one foot lower by daily tapping, and in alternate daily tapping a decrease of 13 to 14 per cent was recorded. But it is now being worked out that this was not the case in budded plants, for budded plants seem to show that as good results might be attained from higher

higher tapping cuts as from lower ones. Various heights from 1 to 9 feet of tapping cuts are under experiment on budded plants in Sumatra.

In Malaya when first opening young trees they go not more than 18 inches above the ground and turn at 33 in. height in the opposite side with an allowance of 1 inch for opening and 2 inches at the bottom.

Methods of applying the cuts.—This consists of the number, the length, the direction, the depth and the inclination of the cuts.

As to the number of cuts and systems of tapping one cut on one half circumference is now considered preferable to the two or more cuts system, not because of the yield but of the diseases which might result by excessive tapping cuts as recorded by the A. V. R. O. S. The yields of 1 cut on one-half, one-third, and one-fourth circumference and 2 cuts on one-third against 1 cut on one-third circumference are as follows:

Estate 1 showed a regular increase of production and Estate 2 a decrease of 25 per cent, but after 6 months the original production was reached from 2 cuts to 1 cut.

Two cuts on one-fourth circumference *versus* 2 cuts on the same side but one cut is placed above the end of the other and about one foot distance. The production showed a proportion of 100: 112.

Two cuts on one-fourth circumference *versus* 1 cut on one-half circumference yielded 100:113.

One cut on one-fourth circumference *versus* one cut one-third *versus* 2 cuts on one-fourth circumference: the production showed the proportions 1 cut one-fourth: 1 cut ⅓: 2 cuts ¼=100: 105: 121.

In the Goodyear Rubber Plantations with the various tapping systems conducted with one cut on one-third circumference daily in rubber planted in 1910, begun February 1920, the results for the 21 months were as follows:

EXPERIMENT 1

System	Average yield in grams per day per tree	Per cent of daily system	Bark renewal in years (tapping 4 feet high)	Per cent of total trees affected by brown bast
1 cut one-third circumference daily	10.6	100	8	4.5
2 cuts one-third circumference 2 weeks	9.2	87	7	5.2
2 cuts one-third circumference alternate daily	8.7	84	8	5.6
1 V cut one-half circumference 2 weeks	7.5	73	10	2.6
1 V cut one-half alternate daily	6.9	62	11	2.3
1 cut one-third alternate daily	5.0	49	15	1.2

This shows that 1 cut on one-third circumference alternate daily is out of the question. The two systems with 2 cuts on one-third circumference gave the best yields.

In the same estate—nine different systems with 1 cut on one-third circumference daily as control were tried on rubber planted in 1913. The results for 6 months were as follows:

EXPERIMENT 2

System	Grams per tree per day	Per cent of daily system	6-year bark renewal	Brown bast per cent of total trees
1 cut one-third circumference daily	6.7	100	38″ high	3.2
2 cuts one-third circumference 2 weeks	6.15	97	40″ high	2.5
2 cuts one-third circumference alternate daily	6.16	98	40″ high	2.7
1 cut one-half circumference 2 weeks	5.8	86	30″ high	.75
1 cut one-half circumference alternate daily	5.6	83	30″ high	1.5
1 V cut one-half circumference 2 weeks	5.5	82	30″ high	1.5
1 V cut one-half circumference alternate daily	5.5	82	30″ high	1.7
2 cuts one-third circumference 3rd daily	4.1	61	....	.75
1 cut one-half circumference 3rd daily	3.1	46	....	.60
1 V cut one-half circumference 3rd daily	3.0	45	....	.50
2 cuts one-third circumference alternate monthly	7.3	109	40″ high	6.0
1 cut one-half circumference alternate monthly	7.0	104	30″ high	2.1
1 V cut one-half circumference alternate monthly	6.5	97	30″ high	2.7

Tapping alternately every third day gave very low yields so after 6 months was changed to alternate monthly.

Comparing the time to finish the operation on different system:

EXPERIMENT 3

TAPPING (BASED ON 12 MEN)

System	Age Years	Time in seconds						Hours and minutes 400 trees	
		Walk	Scrap not done day before	Cut	Cup	Miscellaneous	Total per tree	*hrs.*	*min.*
1 cut one-third circumference	7	6.2	5.0	8.0	6.5	1.3	27.0	3	
	10	6.2	8.0	10.6	7.5	1.5	33.8	3	45
1 cut one-half circumference	7	6.2	6.5	11.4	7.5	1.4	33.0	3	40
	10	......	......	......	......	......	......	......	
V one-half circumference	7	6.2	7.0	14.4	6.5	1.6	35.7	4	
	10	6.2	12.8	20.1	7.5	3.0	49.6	3	30
2 cuts one-third circumference	7	6.2	10.5	19.6	7.5	1.7	45.5	5	
	10	6.2	13.6	24.0	7.5	4.0	55.3	6	10

COLLECTING (BASED ON 12 MEN)

System	Age Years	Time in seconds and tenths				Hours and minutes 400 trees	
		Walk	Collecting	Miscellaneous	Total per tree	*hrs.*	*min.*
1 cut one-third circumference	7	6.0	3.0	0.4	9.4	1	8
	10	6.0	4.0	0.4	10.4	1	10
1 cut one-half circumference	7	6.0	4.0	0.4	10.4	1	10
V one-half circumference	7	6.0	4.0	0.4	10.4	1	10
	10	6.0	5.0	0.4	11.4	1	17
2 cuts one-third circumference	7	6.0	4.5	0.4	11.0	1	14
	10	6.0	6.0	0.4	12.4	1	23

SCRAPPING AFTERNOON (BASED ON 3 MEN)

System	Age Years	Time in seconds and tenths					Hours and minutes 400 trees
		Walk	Scrap	Cleaning cup	Miscellaneous	Total per tree	
							hrs. min.
1 cut one-third circumference	7	6.0	7.2	13.6	1.3	28.0	3
	10	6.0	9.1	13.6	1.3	30.0	3 20
1 cut one-half circumference	7	6.0	8.0	13.6	1.3	29.0	3 14
V one-half circumference	7	6.0	8.0	13.6	1.3	29.0	3 14
	10	6.0	11.0	13.6	1.3	32.0	3 34
1 cut one-third circumference	7	6.0	13.0	13.6	1.3	34.0	3 47
	10	6.0	19.0	13.6	1.3	40.0	4 28

TERMS USED

Walk.—Begins when the tapper picks up the tin basket or can and ends when he sets down at the next tree.

Scrap.—Begins when he sets his basket down and ends when he puts the scrap into the basket.

Cut.—Starts when his knife is in position and ends when putting the bark in the basket.

Cup.—Starts to lift till he replaces it in cup holder.

Miscellaneous.—Not included in any of the above.

Collect.—Reaches out for the cup and ends when replaces the cup.

Clean cup.—Begins when he reaches out for the cups and ends when he replaces the cup.

1⅓ one cut at angle of 30° in ⅓ circumference.
1½ one cut at angle of 30° in ½ circumference.
V½ two cuts at angle of 30° in forming V in ½ circumference.
1⅓ two cuts at angle of 30° in ⅓ circumference equidistant from each other and from the ground.

The table below shows the results obtained during nine months by comparing one alternate system with the standard daily system, namely, one cut on ½ circumference 2 weeks alternate tapping and resting on 4 years old rubber trees.

EXPERIMENT 4

System	1 cut one-third daily	1 cut one-half 2 weeks
	Per cent	*Per cent*
Grams per tree per day	100	63.5
Pounds per acre per month	100	63.0
Rubber content	100	101.0

Experiment 5 showing the per cent of dry rubber in latex from trees of different ages and by different tapping systems:

EXPERIMENT 5

Age of trees in years	Methods of tapping	Dry rubber content of latex
11	1 cut one-third section daily	35.0
10	1 cut one-third section daily	33.6
8	1 cut one-third section daily	33.0
6	1 cut one-third section daily	30.9
6	1 cut one-third section daily	30.4
5	1 cut one-third daily	31.4
11	1 cut one-third section alternate daily	37.6
11	2 cuts one-third alternate daily	35.6
11	2 cuts one-third section alternate 2 weeks	35.4
11	V cut one-half alternate daily	36.2
11	V cut one-half section alternate 2 weeks	36.5
12	1 cut one-third section daily	35.9
11	1 cut one-third section daily	34.3
9	1 cut one-third section daily	34.0
7	1 cut one-third section daily	32.2
7	1 cut one-third section daily	32.0
6	1 cut one-third section daily	31.6
12	1 cut one-third section alternate daily	39.1
9	1 cut one-half section alternate daily	35.5
9	1 cut one-half section alternate 2 weeks	36.7
6	1 cut one-half section alternate 2 weeks	32.9
9	1 cut one-half section alternate months	34.3
9	V cut one-half section alternate daily	35.7
12	V cut one-half section alternate daily	37.4
9	V cut one-half section alternate 2 weeks	37.0
12	V cut one-half section alternate 2 weeks	37.9
9	V cut one-half section alternate months	34.2
12	2 cuts one-third section alternate daily	37.3
9	2 cuts one-third section alternate daily	35.6
12	2 cuts one-third section alternate 2 weeks	36.0
9	2 cuts one-third section alternate 2 weeks	36.9
7	2 cuts one-third section alternate 2 weeks	34.0
9	2 cuts one-third section alternate months	34.2

At the H. A. P. M. experiments comparing the different tapping systems were conducted and gave the following results by years since the beginning of the experiments.

EXPERIMENT 1

Year	Dry rubber in pounds per tree, 1st latex and lump. Yield per acre below in parentheses					Per cent relationship				
	1	2	3	4	5	1	2	3	4	5
1918 (6 months)	.776 (60)	.602 (48)	.626 (48)	.524 (41)	.581 (43)	100	77.6	80.7	67.5	74.9
1919	2.138 (211)	1.777 (175)	1.717 (180)	1.817 (179)	1.907 (184)	100	83.2	80.4	85.1	89.3
1920	2.496 (260)	2.030 (215)	2.27 (233)	2.168 (228)	2.395 (243)	100	84.1	91	86.9	96
1921	2.962 (302)	2.519 (265)	2.594 (268)	2.801 (292)	2.956 (304)	100	85	87.6	94.6	99.8
1922	3.585 (363)	2.863 (303)	3.086 (319)	3.512 (371)	3.483 (363)	100	79.8	86.1	98	97.1
1923	4.032 (372)	3.394 (329)	3.45 (334)	3.745 (368)	3.763 (362)	100	84.2	85.6	93	93.4
1924	4.913 (402)	4.654 (367)	4.772 (388)	5.274 (423)	5.196 (420)	100	94.7	97.1	107.3	105.8
1925	5.310 (425)	5.039 (403)	5.24 (419)	5.624 (450)	5.405 (432)	100	94.9	98.7	105.9	101.8
Total	26.21 (2,100)	22.869 (1,830)	23.755 (1,900)	25.465 (2,039)	23.686 (2,055)	100	87.4	90.6	97.2	98.1

Explanation of the above table:

(1) One-third circumference, 1 left handed cut, 30 degrees angle, daily.

(2) One-fourth circumference, 1 left handed cut, 30 degrees angle, daily.

(3) One-fourth circumference, 1 left handed cut, 30 degrees angle, daily changing to opposite one-fourth every 2 months.

(4) Opposite one-fourth circumference, 2 left handed cut, 30 degrees angle, alternate day.

(5) One-half circumference, 1 left handed cut, 30 degrees angle, alternate day.

EXPERIMENT 2.—*Number of cuts on one-fourth circumference*

Year	Average yield per tapper per year (2 cuts in one fourth circumference)	Average yield per tapper per year (1 cut in one-fourth circumference)
	Pounds	*Pounds*
1914 (7 months)	671.07	643.55
1915	1,307.97	1,282.68
1916	1,979.00	1,987.65
1917	1,929.06	1,896.00
Total	5,887.10	5,809,88

EXPERIMENT 3.—*Three years' results*

Kind and percentages	1 cut left to right 40° every day	1 cut left to right 40° alternate day	2 cuts left to right 40° daily	2 cuts left to right 40° alternate daily	1 cut left to right 27° alternate day	1 cut left to right 33° alternate day	1 cut left to right 45° alternate day	1 cut right to left 27° alternate day	1 cut right to left 33° alternate day	1 cut right to left 40° alternate day	1 cut right to left 45° alternate day
Latex	90.5	90.9	89.9	90.4	90.0	90.9	91.0	90.4	91.0	91.6	90.2
Cup scrap	3.5	3.2	3.2	2.9	3.5	3.3	3.0	3.2	3.0	2.8	3.3
Curly scrap	6.0	5.9	6.9	6.7	6.5	5.8	6.0	6.4	6.0	5.6	6.6

Kind and percentages	2 cuts left to right 40° alternate day	1 cut left to right 40° alternate day	1 cut left to right 40° alternate day	One-fourth circumference 1 cut left-right 27° alternate day	One-fourth circumference 1 cut left-right 33° alternate day	One-fourth circumference 1 cut left-right 40° alternate day	One-fourth circumference 1 cut left-right 45° alternate day	One-fourth circumference 2 cuts left-right 40° alternate day	One-fourth circumference 1 cut left-right 50° alternate day	Opposite one-fourth circumference each left-right 40° alternate day	Opposite one-fourth circumference each left-right 40° daily tap each alternate 2 months
Latex	88.9	89.9	90.3	89.2	89.1	89.1	88.6	88.7	88.8	90.6	90.1
Cup scrap	4.3	3.3	3.5	3.2	3.5	3.7	3.9	3.1	3.7	3.6	3.4
Curly scrap	6.8	6.8	6.2	7.6	7.4	7.2	7.5	8.2	7.5	5.8	6.5

Kind and percentages	Basal V 1 cut one-half circumference 40° daily	Basal V 1 cut one-half circumference 40° daily	1 cut left to right 40° alternate day tap at 10 a.m.
Latex	90.5	90.0	87.8
Cup scrap	3.1	3.4	4.0
Curly scrap	6.4	6.6	8.2

Total crop of 12 plots ⅓ is to 5,705 against 12 plots ¼ is to 4,904, which gave a ratio of 116 is to 110, practically the same as the ratio 117 is 100 quoted from Dr. De Jong.

Total crop of 12 plots left to right is to 5,705 against 12 plots right to left is 5,781, giving a ratio of 100 is to 101, which is a different ratio from that Dr. De Jong gave. He found a difference of 4-18 per cent in favor of left to right.

Total crop of 6 plots tapping every day is: 4,551 against 6 plots alternate day tapping is 3,120, which gave a ratio of 100 is to 69.

In Malaya the following results were obtained from one-fourth spiral cut daily and "V" cut alternate daily as compiled by the Department of Agriculture there.

Estate 1

System	Yield per acre in pounds	
	First year	Second year
One-fourth spiral cut daily	595	563
V cut alternate daily	605	708

Estate 2.—On this property the system was changed from a fairly low, daily third cut, to an alternate day one-half cut. After six months tapping approximately 95 per cent of the former crop was obtained.

Estate 3.—The system was changed from one-third cut daily to one-half cut alternate day and the new system yielded approximately 90 per cent of the former crop.

In Java by daily tapping one-fourth of the circumference the yield obtained was nearly proportionate to the increase in cut up to one-half the circumference. De Jong and Maas obtained the following production:

⅙ : ¼ : ⅓ : ½ circumference = 71 : 100 : 117 : to 118 : 140 one cut daily tapping.

¼ : ⅓ = 100 : 118, ⅓ : ½ = 100 : 120 in one cut alternate day tapping.

2 × ½ : 2 × ⅙ : 2 × ¼ : 2 × ⅓ = 85 : 94 : 94 : 100 : 108 in two cuts daily tapping.

The results of tapping methods conducted at Peradeniya, Ceylon, are given below.

Experiment 1.—Comparing the following:

(*a*) Four cuts 1 foot apart one-third circumference tapped three times a week.

(*b*) Four cuts 1 foot apart one-third circumference tapped twice a week.

(*c*) Four cuts 1 foot apart one-third circumference tapped once a week.

(*d*) Two cuts 1 foot apart one-third circumference tapped three times a week.

(*e*) Two cuts 2 feet apart one-third circumference tapped three times.

(*f*) One cut one-third circumference tapped six times a week—control.

Results for 3½ years: 1912 (6 months) to 1915

Series a		Series b		Series c		Series d		Series e		Series f	
Number of tapping	Yield per tree (lbs.)	Number of tapping	Yield per tree (lbs.)	Number of tapping	Yield per tree (lbs.)	Number of tapping	Yield per tree (lbs.)	Number of tapping	Yield per tree (lbs.)	Number of tapping	Yield per tree (lbs.)
339	12.6	348	11.8	177	6.4	510	11.4	517	11.5	1,026	10.4

In 1914 the trees tapped on 4 cuts 1 foot apart tapped three times a week were tapped in alternate days. In this experiment it has been noted that the yield per tapping increases as the interval of time is increased; and the yield in a given time is greatest with the more frequent tapping too in the 4 cut system. While in the 2 cuts the results were almost identical. The percentage of scrap increases with the tapping interval.

Experiment 2.—Comparing the following tapped in alternate days:

(*a*) Tapped on opposite quarters.

(*b*) Tapped one-third the circumference.

(*c*) Tapped one-third "V" on one-half circumference.

Results from 1910 to 1914

Year	Opposite quarter		One-third circumference		V on one-half circumference	
	Number of tapping	Total yield per tree per tapping	Number of tapping	Total yield per tree per tapping	Number of tapping	Total yield per tree per tapping
1910	64	[a]25.1	37	[c]10.8	....	....
1911	114	[b]30.8	162	47.5	90	[e]27.8
1912	....	....	171	85.5	167	67.6
1913	....	....	139	[d]85.9	148	[d]75.4
1914	....	....	....	....	179	10.5
Total	178	55.9	509	229.7	584	181.8

[a] 5 months. [b] 9 months. [c] 3 months. [d] 11 months. [e] 7 months.

The opposite one-fourth on one-half the circumference showed a greater average yield per tapping than the one-third at the beginning, but its yield became less than the latter after half of the tapping area had been completed. The one-third gave a higher average yield per tapping than the "V."

Experiment 3.—Comparing two cuts versus one cut. The yields for 22 months in pounds per tree and the percentage relationship are given below:

	Yield in pounds			Per cent relationship		
	A	B	C	A	B	C
Single oblique cut (A) to left on one-fourth circumference 15 inches from the ground and opposite quarter a similar cut (B) at 15 inches height and another (C) 12 inches above (B)	7.87	7.7	3.38	100	98	43
Same as above except that the (C) cut was 24 inches above the (B) cut	5	5.57	2.77	100	110	55

In the first the yields of A and B cuts were identical while the C cut was much lower. In the second the yield of B cut was 10 per cent greater than for the A cut, which was made at the same level on the single cut side, and the C cut yielded only one-half as much as the B cut.

Experiment 4.—Comparing "V" with single oblique cut. The results are as follows:

Results from 1914 to 1916

System	Number of tapping	Yield per tree (lbs.)	Per cent scrap
V tapping	543	9.12	11.7
Single cut	543	9.31	12.2

There was only a little difference in yield by the two systems.

Experiment 5.—A change-over tapping has been undertaken at Peradeniya. The following results were obtained.

1. A slightly increased yield was obtained by change-over tapping on one-fourth circumference, but no increase on one-half the circumference.
2. Six months after tapping the bark renewal was better in the change-over than in the continuous tapping on one-fourth, but there was no difference in the case of tapping on halves.

Experiment 6.—Comparing one-fourth, one-third, and one-half circumference at the Henaratgoda Garden, and the results for 3 years are given below compared with the results in Malaya, Java, and Sumatra.

EXPERIMENT 6.—*Results from 1923 to 1926*

System	Ceylon	Malaya	Sumatra	Java
	Per cent relationship	Per cent relationship	Per cent relationship	Per cent relationship
One-fourth circumference	100	100	100	100
One-third circumference	132	121	125	117.5
One-half circumference	192	143	150	145

The percentages of scrap obtained in Ceylon were 11.46 per cent for one-fourth, 9.56 per cent for one-third, and 14.23 per cent for one-half circumference.

Experiment 7.—Comparing the V cut *versus* single cut at Henaratgoda Garden and the results from 1922 to 1925 are given below:

	Pounds per tree
Single cut	12.93
V cut	14.43

Depth of cut.—The latex vessels are situated in the bast in concentric cylinders around the cambium and one cylinder has little connection with the others. As the tapping is done deeper more latex vessels gradually share in the total production, but because of the physiological consideration and the bark renewal tapping should not go deeper than 1 to 1.5 millimeters to the innermost bark.

Direction of cut.—By tapping at the left spiral De Jong assumed 27 degrees to be of 6 per cent, 33 degrees 9 per cent, 40 degrees 10 per cent, and 45 degrees 14 per cent more yield, respectively.

Maas found by tapping 25 degrees of the horizontal at the left increased the spiral to 8.6 per cent and at an angle of 45 degrees an increase of 15.4 per cent.

A cut at 45 degrees yields more than at 25 degrees, but this extra yield is very small contrasted with the excessive bark consumption, so the angle is now not more than 25 degrees. Doing the tapping to the left is recommended because of the increase of yield to 3.5 per cent more than when made to the right.

Excessive tapping produced watery latex and thus less rubber content and also injured the trees.

Time interval in tapping.—At the H. A. P. M., Sumatra the following results were obtained by daily, alternate day and periodic tapping.

1. Twelve replications of five series of plots as follows:

   a. Tapped two weeks, rested 2 weeks.
   b. Tapped one month, rested 1 month.
   c. Tapped two months, rested 2 months.
   d. Tapped four months, rested 4 months.
   e. Tapped six months, rested 6 months.

2. The percentage relationship of yield of first latex dry rubber for two years' tapping was as follows: (1) 100.9, (2) 100, (3) 99.5, (4) 91.6, (5) 86.8. Or, in other words, the fortnightly alternate, monthly, and bimonthly plots gave practically equal

yields while the 4-monthly and 6-monthly plots gave inferior yields. In all cases the maximum yield was given in the second fortnight's tapping and for the longer tapping periods the yield in the succeeding fortnights fell off until the 5th fortnight, after which it was more or less constant.

3. The per cent concentration from total latex and dry rubber produced in the two years was as follows:

a. Alternate fortnightly plots, 39.9 per cent.
b. Alternate monthly plots, 38.7 per cent.
c. Alternate 2 monthly plots, 38.1 per cent.
d. Alternate 4 monthly plots, 36.6 per cent.
e. Alternate 6 monthly plots, 35.3 per cent.

In all cases the dry rubber content was higher in the first fortnightly tapping.

4. The rate of vulcanization of the samples from the trees immediately after the short periods of rest, viz., ½ month and 1 month, is as slow as for the longer periods of rest of 2 and 4 months, but not quite as slow for the 6 months. The final rate of vulcanization of the rubber from the trees rested for 4 and 6 months is also faster than for the shorter resting periods, so that the total variation is greater for the longer resting periods.

5. Tapping alternate months one-half of the circumference is the most desirable system.

Experiment 1.—In alternate months on one-half cut against alternate day on one-half cut in red and white soil: On white soil after 14 months' tapping alternate month plots were 3 per cent above the alternate day plots. The following yields were obtained.

Year	Pounds dry rubber per A. first latex		Per cent relationship	
	Alternate days	Alternate months	Alternate days	Alternate months
1922 (10 months)	234.76	225.86	100	96.2
1923	290.28	322.21	100	104.4
1924	505.66	548.99	100	108.6
1925 (1 month)	41.80	39.06	100	93.4
Total	1,072.50	1,136.12	100	105.9

The alternate monthly tapping is also more favorable than the alternate day system on red soil as shown on the above table. The alternate month system yielded 6 per cent more after 35 months tapping.

Experiment 2.—Tapping 1 month, resting one-half month on one-half cut *versus* one-third daily:

System	Pounds dry rubber per acre					
	1922 (5 months)	1923	1924	1925 (1 month)	Total	Per cent relationship
One-third cut daily	136.6	358.2	353.0	40.85	888.6	100
One-half cut tapped one month and rested one-half month	138.8	372.0	363.0	33.76	908.1	102.2

The above yields include first latex, lump, can, cup, and bark. The balance is slightly in favor of tapping one month and resting ½ month on the one-half cut. This system gave 2 per cent more than the one-third cut daily. Also the percentage of lower grades is more for the one-third daily system, which makes it also undesirable.

Experiment 3.—Alternate monthly one-half cut *versus* one-third cut daily, gave the following:

System	Pounds dry rubber per acre					
	1922 (2 months)	1923	1924	1925 (1 month)	Total	Per cent relationship
One-third cut daily	53.7	371.59	274.31	27.69	727.29	100
One-half cut alternate months	42.47	302.4	318.16	26.19	689.22	94.8

The advantage of the alternate month tapping lies in the greater economy of management and tapping as well as in the increased amount of first latex rubber. The above include lump, cup, can, and bark rubber.

Experiment 4.—Length of resting period gave the following results:

1. Alternate fortnights
2. Alternate months
3. Alternate 2 months
4. Alternate 4 months
5. Alternate 6 months

One-third circumference and bark consumption is 2 inches per tapping month.

Date	Yield in lbs. of dry rubber per tree					Per cent relationship				
	1	2	3	4	5	1	2	3	4	5
May 1923, to December 1923	1.901	1.891	1.918	1.701	1.795	......	100	......	......	......
January 1924, to December 1924	5.123	4.074	5.061	4.730	4.611	......	100	......	......	......
Total	7.024	6.965	6.979	6.431	6.406	100.8	100	100.2	92.3	92

No. 2 or alternate month plots are taken as control in the above table.

Experiment 5.—Comparing 2 months' tapping with 1 month rest, 2 months' tapping with 2 months' rest, 1 month's tapping with 2 months' rest against alternate day on one-third of the circumference. The results for 14 months gave the proportion of yields as follows:

101.8 per cent for 2 months' tapping and after 1 month's rest.
98.2 per cent for 2 months' tapping and after 2 months' rest.
103.1 per cent for 1 month's tapping and after 2 months' rest.
102.8 per cent for alternate day (only first grade rubber).

Two months' rest was apparently not so good as one month's rest in tapping for 2 months, the result of tapping 1 month after 2 months' rest actually being higher than 2 months' tapping with 1 month's rest and tapping alternate days gave a lower yield than tapping 1 month with 2 months' rest.

In another field from one month's tapping and resting a fortnight 101.2 per cent of all grades was obtained in 5 months.

The 2 months' alternate tapping gave as good results as monthly or fortnightly alternate, whereas 4 and 6 months gave somewhat poorer returns.

In Malaya the majority of the well-kept estates are now tapping alternate days, and a few do periodical tapping. It has been found that alternate day tapping produces about 70 per cent of the yield as compared with a daily over a given period, with equal lengths of tapping cut, but if the length of the cut in the alternate day system is increased, it makes a more favorable comparison. Besides alternate day tapping is recommended from the disease point of view. During 1920 the trees were tapped daily on one-fourth cut and during 1921 and 1922 they were tapped alternate day with one-fourth cut and the following yields were obtained from Estate 1.

Year	Yield per acre	Yield per tree	Cost of tapping
	Pounds	*Pounds*	*Centavos*
1920	220	2.66	9.04
1921	203	2.59	5.62
1922	257	3.28	4.81

Estate 2.—When the trees were 10 years old a change was made from daily to alternate day, one-fourth cut. It is reported that 15- to 16-year old trees are producing rather more on a one-fourth cut, alternate days, than they did at the age of 10 to 11 years when they were tapped daily.

Estate 3.—An interval of more than 2 days gave the following:

Tapping system	Area (A)	Interval of tapping	Total yield	Yield per acre	Number of tapping months	Bark consumption (inches per year)
			Pounds	*Pounds*		
V on one-half the circumference	10	Alternate day	2,765	276	10	9
	20	Every 3 days	5,341	267	11	6

In Malaya it has been found that resting from one-half to 2 months is the best tapping interval.

In Java as elsewhere it has been observed that daily tapping yielded more than the alternate daily, but the cost is greater and the disease is more prevalent on trees tapped daily. The first quality of rubber obtained was greater from alternate daily than daily tapping. No gain was made by using 3-day intervals. The periodical tapping should not last longer than 2 months, or less than 1 month. The time varies from one-half to 2 months in Java. After one month's rest the yield is higher than after one-half month's rest. Half-month's tapping appeared to be too short. Continued tapping for two months after one month's rest resulted in a good total yield, but did not give satisfaction, for the production during the second month and the rubber content decreased.

At the Goodyear Rubber Plantations they obtained the following results from alternate daily, 15 days' rest with 15 days' tapping, and 30 days' rest with 30 days' tapping by various tapping systems:

EXPERIMENT 1

Period	Daily	Alternate daily			15 days' rest, 15 days tap				30 days' rest, 30 days tap		
Tapping cut	1/3	2/3	1/2	V-1/2	2/3	1/2		V-1/2	2/3	1/2	V-1/2
Age of trees at beginning	4 and 8 years	8	8	8	8	8	4	8	8	8	8
1–3 months	100	100	77.5	77	94	78	69	71	104	99	90
4–6 months	100	100	76.5	78.5	101	84	61	81	95	94	90.5
7–9 months	100	90	79	76.5	92	87	81	80	96.5	99	93
10–12 months	100	92.5	94	88	85	85.5	95	75	94	97	98.5
13–15 months	100	91	94	93	84	86	90	83	110	118	111
16–18 months	100	86	97	96	79	82.5	94	86	108	113	116
19–21 months	100	99	111	104.5	99	112	84	114	......	......	......
22–24 months	100	100.5	105	100.5	96	100	....	98	......	......	......
Average for first year	100	95.5	82	80	93	83.5	76.5	77	97.5	97	93
Average for second year	100	94.5	102	98.5	89.5	95	89[a]	95	109[b]	115.5[b]	[b]113.5
Per cent of cases of brown bast to December 1922	32.5	24.2	17.0	11.8	15.2	11.8	....	6.9	27.2	18.6	13.6

[a] 9 months. [b] 6 months.

The results of the time intervals of tapping at Peradeniya, Ceylon, are given in the tables below in pounds.

Results from 1912 to 1915

Alternate days			Alternate months			Alternate days			Alternate months		
4 cut 1 foot ¼			4 cut 1 foot ¼			2 cut 1 foot "V"			2 cut 1 foct "V"		
Number of tapping	Yield per tree	Per cent scrap	Number of tapping	Yield per tree	Per cent scrap	Number of tapping	Yield per tree	Per cent scrap	Number of tapping	Yield per tree	Per cent scrap
681	9.3	15.5	698	10.4	13.1	681	10.7	15.5	697	11.0	11.3

Under both systems of tapping the alternate months gave a greater total of yields and less percentage of scrap than the alternate days. And the V system has proved better than the ¼ circumference using 2 and 4 cuts, respectively. The trees serving for this experiment were planted in 1905 and by December 1911, they had an average girth of 25, 24.7, 25.5 ,and 24.3.

Experiment 2.—Comparing 2 alternate days with 3 alternate days, and the yields per tree of dry rubber including scrap from 1919 to 1925 are given below:

Results for 7 and 3 years

	Two days alternate				Three days alternate			
7 years 1919–1925	1	3	5	Average yield and per cent diseased	2	4	6	Average yield and per cent diseased
Yield in pounds	26.12	28.19	29.56	27.95	18.25	19.12	22.25	19.87
Brown bast	3	......	......	3.7%	......	......	......	......
Bark rot	9	1	1	13.3%	3	1	1	5.8%
Canker	3	1	1	6.4%	......	1	......	1.2%

	Single cut 16°				Single cut 16°			
3 years 1922–1925	1	3	5	Average yield and per cent diseased	2	4	6	Average yield and per cent diseased
Yield in pounds	11.87	13.12	11.56	12.18	9.93	9.56	10.18	9.89
Brown bast	4	1	1	3.6%	2	......	......	1.2%
Bark rot	3	9	3	8.9%	1	3	2	3.6%
Canker	5	4	4	7.8%	2	2	......	2.3%

As may be noted from the table the yields from the two days alternate were greater than for the three alternate days, but more trees affected with diseases compared with the latter.

Experiment 3.—Comparing alternate days, alternate months, and alternate two months gave the following results from April 7, 1922, to 1925.

	Alternate days			Alternate months			Alternate 2 months			Average daily tapped
	1	6	Average	2	4	Average	3	5	Average	
Yield in pounds	13.25	11.81	12.53	12.0	12.25	12.12	12.37	12.75	12.56	12.31

During the whole period there was no significant difference in yield, but as to diseases the brown bast was worse in the block tapped in alternate days during the first year while the latest figure was 6.3 per cent against 8.2 per cent of the block tapped alternate months.

Experiment 4.—Comparing tapping once, twice, and thrice a week on one-third circumference, with 4 cuts to the left, one foot apart, the following results for 6 years were obtained:

Interval	Total yield in pounds	Per cent relationship
Once a week	11.4	44.3
Twice a week	23.4	90.7
Thrice a week	25.8	100.0

Tapping three times a week gave more total yield than tapping twice or once a week only. The yield per tapping in twice per week was greater than in thrice per week tapping. While tapping once per week did not give a greater yield per tapping than tapping thrice a week.

The quantity of rubber was greater from the most frequent tapping, and the percentage of rubber increased as the time interval increased.

Experiment 5.—Comparing alternate daily, once a week, thrice a week, and six times a week with the different number of cuts, etc. The yields from 1912 to 1918 or for a period of 6 years are tabulated below:

Results for 6 years

Plot	Interval of tapping	Tapping days	Total yield	
			Per tree	Per tapping
			Pounds	*Ounces*
1	Thrice a week on 2, 5 and 3 cuts 1 foot apart	946	25.75	0.44
2	Twice a week on 4 cuts, 1 foot apart	605	23.38	0.62
3	Once a week, 4 cuts, 1 foot apart	308	11.38	0.59
4	Thrice a week on 2 cuts, 1 foot apart	892	20.31	0.36
5	Thrice a week on 2 cuts, 2 feet apart	901	19.75	0.35
6	Six times a week, 1 cut, 3 feet apart	1,757	19.38	0.18

The yield per tapping was greater in twice per week than the others. The most frequent tapping produced the greatest quantity of rubber. The percentage of rubber in the latex increased as the time interval increased.

Tapping intervals were tried on 3 cuts 1 foot apart on V at the Henaratgoda Garden and with the following results:

Results from June 1908, to June 1913

Interval	Total yield	Number of tapping days	Yield per tapping whole period
	Pounds		*Grams*
1. Daily	112	923	65.0
2. Alternate days	122	675	82.0
3. Every third day	94	458	93.0
4. Every fourth day	92	348	121.0
5. Every fifth day	89	271	150.0
6. Every sixth day	81	228	161.0
7. Every seventh day	62	201	141.0

The total yield was greatest when trees were tapped at the shortest interval, but the yield per tapping was greater as the interval of time increases, except in the last one.

Bark renewals were poorer on trees tapped daily than those tapped alternate days, every third day, and so on.

It is now generally agreed that, apart from the exhaustion of bark, trees may be so heavily tapped that they lose vitality and become prematurely old. Estates which are content with what they can get by alternate day tapping have certainly a far better prospect of a long life than those which, in their eagerness for immediate profit, take little thought of the future.

The planters now mostly favor the alternate day or monthly periodic tapping on either one-half, one-third, one-fourth, or a V cut. In Malaya the one-fourth circumference and the V cut (one-half of the circumference) are considered the best, while in Sumatra the one-half. In daily tapping the cut should not exceed one-third of the circumference.

Thickness in shaving.—At the H. A. P. M. it has been found that the percentage relations of yield to thickness of shaving were: 1, 1½, 2, and 2½ inches shavings equals 78, 100, 130, and 130, respectively. An inch for opening and another 2 inches at the bottom have been allowed. An experiment comparing the yields of 1, 1½, 1¾, and 2½ inches shaving monthly on trees planted in 1910 gave the following results:

Shaving per month (inches)	Dry rubber pounds (6 months)	Yield per tree (6 months)
2½	163.1	3.312
1¾	132.7	2.679
1	106.9	2.160
1½	130.8	2.649

There is rather a wide range in the percentage of increase caused by the thickness of the shaving. In the case of thick shaving the increase varied from 21.6 per cent to 31 per cent. For thin shaving the decrease varied from 16.8 per cent to 26.9 per cent.

In Java a bark consumption of 1:1½; 2:2½ inches per month equals 60.5:77.5; 100:101, and of the 1.56:2 inches =80·5:100. The daily tapping was carried to not more than 1½ inches or a little more, in alternate daily not less than 0.9 to 1 inch, and periodical tapping not less than 1¾ inches per tapping month.

In Malaya the bark consumption was 1½ to 2 inches monthly for daily tapping and three-fourths to 1¾ inches on alternate day tapping. It should not be done too thin for the first week after rest.

Bark renewal.—At the Goodyear Plantations, Sumatra, the bark renewal by using different tapping systems was compared, and gave the following results:

System	1 cut on one-third circumference daily	1 cut on one-third circumference alternate daily	V on one-half circumference alternate daily	V on one-half circumference alternate biweekly	2 cuts on one-third alternate daily	2 cuts on one-third alternate bi-weekly
Average monthly bark consumption in inches........	1.45	0.80	0.73	0.81	1.45	1.65
Number of years renewal, tapping 38 inches high....	7½	13½	6	6¾	7½	6½

At the H. A. P. M. the yields with per cent relationship of the five series of bark renewal have been as follows:

Month	Yield in pounds of dry rubber per acre					Per cent relationship				
	5 years	5 years	5 years	4 years	4 years	5 years	5 years	5 years	4 years	4 years
	(10 mo.)	*(6 mo.)*	*(2 mo.)*	*(10 mo.)*	*(6 mo.)*	*(10 mo.)*	*(6 mo.)*	*(2 mo.)*	*(10 mo.)*	*(6 mo.)*
May...........	.262	.283	.287	.294	.318	100	108.0	109.6	112.2	121.4
June...........	.305	.305	.299	.285	.262	100	100	98	93.5	85.9
July...........	.422	.402	.370	.376	.382	100	95.3	87.7	89.1	90.5
August........	.459	.432	.425	.435	.388	100	94.1	92.6	94.8	84.5
September.....	.499	.470	.441	.442	.445	100	94.2	88.4	88.6	89.2
October........	.483	.479	.457	.453	403	100	99.2	94.6	93.6	83.4
November......	.510	.513	.460	.442	.453	100	100.6	90.7	86.7	88.8
December......	.518	.505	.459	.509	.448	100	97.5	88.6	89.3	86.5
Total....	3.458	3.389	3.198	3.236	3.099	100	97.9	92.5	93.5	89.5

The oldest bark gave the highest yields.

The thickness of the renewed bark was shown to increase with the age, but no such advantage in number of latex vessels appeared to result from the longer renewal.

Trees with the most renewal are also the worst yielders as indicated below:

Class	Number of trees	Average yield per tree
		Grams
1. Well-renewed bark free from wound	392	4,010
2. Slightly inferior to 1 but which can be tapped without difficulty	378	2,940
3. Poor renewal and badly wounded. Difficult to tap. Improvement doubtful	153	2,030
4. Hopeless trees from renewal standpoint	40	1,380

In white soil and on 12-year-old trees the following points were observed:

1. The thickness of 4-year renewed bark is about 70 per cent of the virgin bark and the rate of renewal in the following years is probably extremely slow.
2. The number of latex vessels in 4½ years' renewed bark is about the same as in virgin bark and the number in 3½ to 4 years' renewed bark is about 85 per cent that of virgin bark. A longer renewal period than 4½ years will probably result in only a slight increase in the number of latex vessels.
3. A longer renewal period than that required to obtain bark of tappable thickness is probably unnecessary from the standpoint of yield alone. What the effect of a short renewal period would be as regards the general health and vigor of the tree remains to be determined.
4. Five years' renewal is sufficient, especially with thinning out and manuring.
5. The alternate days tapping gave 7 per cent better renewal than one-half cut daily.

The bark renewal of budded plants compared with seedlings at H. A. P. M. is tabulated below:

	Budded plants	Non-budded plants
Number of tree	51	45
Bark thickness:		
Virgin	304.8	312.6
Renewed	224.5	223.8
Percentage	73.5	70.9
Latex vessels:		
Virgin	21.4	23.2
Renewed	19.0	23.8
Percentage	88.8	102.6

In Java the bark renewal was 5 to 6 years. The thickness of the renewed bark after 3 to 4 years has not yet reached normal and for second and third bark renewal longer periods were adopted, i. e., 7 to 8 and 8 to 10 years. However, soil-manuring and thinning out affect the renewal of bark. A 5-year bark renewal is quite sufficient on manured trees and on rich soil.

In Malaya 4- to 8-year bark renewal is being considered, but they take into consideration the soil and other factors.

Tapping systems on budded plants.—It has been found in Sumatra that budded plants behave differently from seedlings.

1. One week, 2 weeks, and 1 month have been compared on 1 cut of one-half of the circumference. The yields obtained indicate that no advantage is to be expected from either alternate week or alternate 2 weeks tapping using a single cut.

2. One cut *versus* two cuts.

a. Two cuts alternate one week, 2 weeks, one month.

b. One-half of the circumference with the upper cut 42 inches above the lower.

So far there has been no apparent falling off in yield. The alternate week or two weeks gave the greatest increase in yield, amounting to approximately double that of the control in the last period of tapping. There has been no apparent increase in brown bast attack due to the drastic tapping system employed.

3. By tapping the entire circumference in a "V" cut a comparatively small increase was secured, but not proportional to the increased bark consumption. None of the trees have been attacked by brown bast.

Effect of monsoon on tapping.—In Burma, Indo-China, and Siam especially tapping can only be performed for 8 or 9 months because of the drought. During the dry season the flow of latex is greatly lessened. In Ceylon tapping is restricted by rains. In some estates tapping is not performed regularly during 3 or 4 months of the year because of morning rains. In Malaya, Java, and Sumatra, in some of the estates tapping is not practiced when the trees are wintering, which takes about 2 months. Planters in those localities pointed out that this compulsory resting of trees is a real benefit from the standpoint of diseases.

During the dry part of the year it is very advisable to rest the trees. In Ceylon resting takes place for 4 to 6 weeks, in Indo-China 4 weeks; in Sumatra and Federated Malay States there is no resting period because of the equable distribution of rainfall, except during the wintering period.

Tapping materials.—In Malaya the gauge, the Jebong, and the chisel-like tapping knives were commonly used, while in Java and Sumatra mostly the Jebong knife. The Bamber and the Northway prickers have never proved practical in tapping Para rubber nor the many patent tapping knives in Ceylon. Coconut shells are used as collecting cups in Ceylon; and in Malaya, Java, and Sumatra aluminum, earthen, or glass cups are employed. A very satisfactory cup holder has been devised. A mixture of sulphur and cowdung is applied on newly tapped bark to make the bark renewal easier in Ceylon.

Tapping task.—In working out the average in a tapping task, several factors are taken into consideration, such as age and size of trees, planting distance or interval between trees, tapping system in use, the distance from the factory or coagulating shed, etc. A tapping task of 250 to 500 trees in Malaya, Java, Sumatra, etc., is assigned per tapper; and 150 to 250 trees on hilly land.

Collecting.—Besides the collection of the first grade latex there is also the collection of scrap, bark shavings, etc., from the field. This is done either in the morning or in the afternoon. Both ways have advantages and disadvantages.

It is better to have a tapper finish tapping early in the morning, say about 8 o'clock, than at 9 o'clock for the following reasons:

a. It is cooler and the latex does not coagulate so quickly as it does later in the day, thus giving a higher percent of first grade rubber.

b. Sufficient time is given for the latex to run before collecting that the latex should be collected before it gets too warm.

By scraping or collecting the scrap in the afternoon the tapper may be able to tap 400 trees 10 years old in 2½ hours, while if he does not collect the day before, he can only tap 300 in the same length of time. The only difficulty about doing this in the afternoon, is that the tapper will have less time to clean the trees and spouts, wash the glasses, and to sweep around the trees. The cups need not be washed if they are scraped and wiped out in the afternoon, however. Furthermore, scraping the same day causes a little latex to start running on over half the trees, which adds a little to the scrap rubber.

MANUFACTURING

The following directions for the manufacture of raw rubber were issued by the Rubber Experiment Stations in the Dutch East Indies for the guidance of the planters there and are here reproduced for our planters.

TREATMENT OF LATEX

1. When tapping the *cups* must be dry; so far as possible, ensure that no water is added to the latex in the field. The *rubber content of the latex* should be 30 per cent or higher with daily tapping; 33 per cent or higher with alternate day tapping; with periodical tapping 40 per cent to 45 per

cent shortly after the resting period and gradually decreasing to 35 per cent or 30 per cent, according to the tapping system.

2. Use a squeezer for *emptying* the cup (preferably of wood with a rim of rubber). Keep the latex *cool.* Close the cans with a *cover.*

3. If difficulties arise from *premature coagulation or lump formation* in the latex, efforts should be made to avoid them, by cleansing the spouts and cups, collecting the latex earlier and preventing the addition of water in the field.

Only when these precautions give no improvement should an *anticoagulant,* such as soda (sodium carbonate) be used (5 to 10 per cent solution of powdered anhydrous soda per liter of latex). If the estate is manufacturing crepe the stronger disinfectant, sodium sulphate, may be used (6 cc. of a 10 per cent solution of anhydrous sodium sulphite).

4. When *receiving* the latex, it should be carefully poured into measuring pails through a coarse sieve to separate the lumps and the larger pieces of dirt. A deposit containing sand, etc., remains in the cans and should be poured into a separate jar. Weighing the latex into the measuring pails is more practical than measuring.

5. A coagulating test of 50 cubic centimeters per tapper is recommended.

6. The latex should be passed through two sieves placed on the top of the mixing tank. For these sieves copper plate should be used with a perforation of 1 millimeter and one-half millimeter for the upper and lower sieves, respectively; for the lower sieve a centrifugal gauge may also be used. Do not tap on or shake the sieve, nor rub with the hands or a piece of coagulum; use a wooden spatula for cleaning or rub the sieve gently with it; change the sieve as soon as the latex flows too slowly.

7. Bulking all the latex into one *mixing tank* is to be preferred. The best dimensions are: breadth 1 meter; depth not more than 90 centimeters length, according to the quantity of latex to be expected.

8. Determine the *concentration of the latex* in the mixing tank by means of a coagulating test in one-half or 1 liter, coagulated with 100 cubic centimeters of acetic acid of 2 per cent concentration or 200 cubic centimeters of formic acid of 1 per cent concentration.

9. Dilute to *standard concentration of 20 per cent dry rubber contents,* according to coagulation test and table. For diluting use perfectly clean water, which if necessary should be specially supplied. Stir with a paddle slightly narrower than the tank with holes of 5 centimeters diameter.

MANUFACTURE OF SHEET

10. *Standard weight* 1.5 kg. dry manufactured from 7½ liters latex of 20 per cent concentration. *Small* standard weight 1 kg. dry, manufactured from 5 liters latex of 20 per cent concentration. *Breadth* 45 centimeters (breadth of sheet). Thickness 3 to 3½ millimeters over the ribs. *Length* about three times, or small sheets twice the breadth of the sheet.

11. Use *coagulating pans or tanks* of standard dimensions (see the guide to the preparation of rubber, pages 27 and 29).

12. *Sodium bisulphite* should be used only as an exception (e. g. during wintering) and not more than one-fourth gram per liter of latex of 20 per cent concentration.

13. One and one-fourth to 1¾ grams of *acetic acid* diluted to 20 per cent concentration should be added to the latex or 60 to 90 cubic centimeters per liter of latex of 20 per cent per pan of 7½ liters. This is 450 to 650 cubic centimeters per pan of 5 liters 300 to 450 cubic centimeters.

When using *formic acid,* as a rule half the quantity used for acetic acid coagulation is necessary; formic acid should be used preferably in a solution of 1 per cent concentration.

When an anti-coagulant is used, and also under certain conditions (wintering, reopening of the tapping cut) the quantity of acid must be increased somewhat.

Do not pour in the acid in one place, but distribute it evenly from the beginning.

14. *Stir well,* especially along the sides and in the corners, with a paddle with holes. *Skim off carefully;* cover the pans well to prevent dirt or dust dropping in.

15. *Mangle* the sheets the *same day.* Roll the edges and corners especially with a *hand roller.* Do not make the sheets too thin or too hard in the smooth rollers, else the pattern will not take. Use the *standard spiral pattern.*

16. *Keep* the sheets *under water* the first night, preferably as well separated from each other as possible. If soaking during one night is objectionable, then brush the sheets well after priming and consult the experiment station.

17. Hang the sheets *to drip* in a draughty place, far from each other; preferably in an open gallery or in the open air early in the morning. After some hours the surface should be dry and then the sheets should be transferred to the smoke house. On no account let the sheets stay in the factory overnight (danger of rustiness).

18. Use dry wood for *smoking.* Take care that there is sufficient ventilation during the first days as much moisture must be carried away. Hang the sheets in rods and turn these regularly. Maintain a temperature of 40° C. to 50° C., the thermometer hanging between the sheets.

19. Control the *dry weight per sheet* regularly. Sheets with particles of dirt should be sorted out carefully. When *defects* or *deviations* occur, consult the Guide to the Preparation of Rubber and send a sample to the experiment station.

MANUFACTURE OF CRÊPE

20. *Standard breadth* 23 to 24 centimeters (half the breadth of the sheet). Standard thickness 1 to 1½ millimeters.

21. *Sodium bisulphite* three-fourths to 1¼ grams per liter latex of 20 per cent concentration. To be added as a solution of 5 per cent concentration or in part of the water used for diluting (solution not stronger than 5 per cent). Stir well after adding the bisulphite and skim off. Directly afterwards the acetic acid can be added.

22. *Acetic acid* 1 to 1⅓ grams per liter latex of 20 per cent concentration. To be added as a solution of 5 per cent concentration or in part of the water used for diluting (solution not stronger than 5 per cent).

When using *formic acid,* as a rule half the quantity of acetic acid used in acetic acid coagulation, suffices; use a solution of not more than 2½ per cent concentration. Stir well, then skim off. Cover the coagulating tanks carefully.

23. Work up the coagulum the *next day.* Use water on the roller abundantly. Do not let the crêpe stay too long in the factory, but hang it up at once to drip. Start *drying,* as soon as possible; when kept the crêpe becomes harder and dries more slowly.

24. Cut out pieces of dirt and spots. When *defects* and deviations occur, consult the Guide and send a sample to the experiment station.

LOWER GRADES

25. Work the lower grades up into *compo;* black scrap and earth rubber separately. When yields are high the bark shavings should be washed in a washing machine; with small yields the best thing to do is to have the scrap sorted out by hand. Provided that this tree scrap is sufficiently free from particles of wood, it can be worked up into compo.

26. If no washing machine is available the crêpe should be given a uniform appearance (without streaks) by thorough mangling.

27. Finish the crêpe to a breadth of 23 to 24 centimeters (half the breadth of the chest) and a thickness of 1½ to 2 millimeters.

PACKING

28. Do not take more rubber into the packing room than can be *sorted and packed the same day.* Do not let the rubber stay unpacked overnight, or it will absorb moisture.

29. Before filling the chest, *line* the inside with sheets, first the corners, then the sides.

30. Rubber of standard dimensions should be packed; crêpe 70 to 75 kg., sheet 100 kg., brown crêpe 65 kg., per veneer chest of 19 by 19 by 24 inches. On no account pack more than 80 kg. crêpe or 105 kg. sheet.

Coagulating.—Aluminum coagulating tanks for the manufacture of crêpe and aluminum pans for the smoked sheet rubber are standard equipments in most estates instead of cemented tanks or eathern jars and enameled pans for coagulating. They were cleaner, durable, and more economical in the long run compared with the enameled pans and glazed tanks. A large-sized aluminum tank holding approximately 200 pounds of dry rubber measuring 12 feet by 4 feet by 10 inches costs about ₱431.00. A small one holding 100 pounds of dry rubber costs ₱230.00.

After the latex has been passed through a sieve of one-third inch mesh at the upper and with finer mesh at the bottom, generally that for crêpe is coagulated in tanks and with stronger acid concentration of either acetic or formic acid, while latex for standard smoked sheets is coagulated in wooden boxes or enameled or aluminum pans of varying sizes, some 68 by 33 by 6 centimeters and of lesser concentration of coagulant.

Tanks lined with glass or glazed tiles and with glass or aluminum partition are also in use. Good smoked sheets can not be made if the latex is coagulated in tank. Standard sheets are made only from latex coagulated in pans and these are distinguished with their rounded edges. The coagulums are milled the following day. In making crêpe rubber, especially if it is to be made into sole crêpe, a fractional coagulation has been found beneficial. The process is described elsewhere in this report.

The latex is diluted with water to approximately 1¼ to 1½ pounds dry rubber per gallon before a coagulant of three ounces or a five per cent aqueous solution is added for smoked sheet and 6 liters of this latex poured into every coagulating pan, which makes 1.2 kilograms dry sheet, 96 by 41 centimeters by 5 millimeters. And for crêpe less water is added or none at all, but instead a small quantity of bleaching agent (sodium bisulphite) to give the finished crêpe a pale color. The addition of water to the latex makes the coagulum soft and hence easy to work.

For practical purposes to latex from young trees one-third as much water is added and three-fourths to latex obtained from old trees. Stir before adding the acid.

The coagulants are prepared as follows:

1. For smoked sheet 1 to 2½ per cent acetic acid has been found sufficient and for crêpe 5 per cent is used in the ratio of 1: 80 or up to 1: 280 or 0.75 to 1 gram acetic acid per liter of 15 per cent latex.

2. *Formic acid* has recently been tried as a coagulant and is becoming popular in many large estates because it is more efficacious and reduces the cost of the coagulant to about half of the cost of the acetic acid.

The stock solution is made of 50 parts of 85 per cent formic acid mixed with 50 parts of water and 1½ cubic centimeters of this solution is put into 1 liter latex or 5 cubic centimeters of formic acid of 1½ per cent solution per kilogram dry rubber or 3.2 cubic centimeters per kilo dry rubber.

3. Sodium silico-fluoride, it is claimed, is a preventive of bubbles in smoked sheet, and it is slightly cheaper in application than the acetic acid acting as a mould preventive and easy to handle. Complete directions for its use as given by Mr. J. Edwards of the Pataling Estate, Federated Malay States, are as follows:

"FOR SHEET

"*Preliminary treatment of latex.*—If necessary sodium sulphite may be used in the field and in the factory in the proportions recommended in the Rubber Growers' Association handbook, *The Preparation of Plantation Rubber (1917)*.

"*Standardization.*—The latex should be diluted to 1½ pounds per gallon by means of the metrolac.

"*Proportion to use for coagulation.*—One pound of sodium silico-fluoride to 150 gallons of standard latex.

"*Method of use.*—The weighed quantity of the chemical should be introduced into the coagulating tank and the standardized latex run in and thoroughly stirred. This is best done by means of a stirring device consisting of a board perforated with a number of holes, which is moved up and down the length of the tank by means of a long handle. Coagulation should take place in one-half to three-fourths hour."

"FOR CRÊPE

"*Preliminary treatment of latex.*—Sodium sulphite can be used in the field, as in the preparation of sheet rubber (see under "Sheet"). Sodium bisulphite should be used in the proportion 1½ pounds (dissolved in 10 gallons of water) to 150 gallons of standardized latex. This should be added to the latex in the bulking tank before it runs into the coagulating tank.

"*Standardization.*—The latex should be diluted to 1½ pounds per gallon as described under "Sheet." A greater rubber content is not recommended.

"*Proportion to use for coagulation and method of use.*—Proceed as in the case of 'Sheet'."

4. Alum and sulphuric acid have been tried during the early days in the preparation of plantation rubber and the former is still in use by the native planters.

Fractional coagulation.—To make the crêpe pale or white 1 part of sodium bisulphite to 800 parts latex or fractional coagulation was used or both combined. The method used differs considerably. In many cases, however, bisulphite of 25 to 30 per cent and afterwards one-third to one-half gram of acetic acid is added to every liter of latex. After one-half to 1 hour the clots are skimmed off, the remainder is strained again, and the rest of the acid is added. In a few cases the bisulphite is added to the undiluted latex and the acid then added.

Another system to obtain a pale crêpe is by mixing a little blue powder (ultramarine) with the latex. The yellow color is neutralized in this way and the effect is really surprising. A gram of this blue powder is sufficient for 50 liters of latex.

Complete directions for partial coagulation as recommended by Mr. J. Edwards of the Federated Malay States are as follows:

PARTIAL COAGULATION. RECOMMENDATION FOR ESTATE PRACTICE

The latex used should not be treated with an anticoagulant in the field, but bisulphite should be introduced into the bulking tank in the proportion of 1 pound dissolved in 10 gallons of water to 100 gallons of latex, the latex being standardized to 2½ pounds per gallon. (If the proportion of bisulphite recommended is added to *sulphited* latex, a first clot cannot be obtained by the addition of acid in the proportion of 1: 3,600.)

A suitable proportion of acid to use is 1 gallon 1 per cent acetic to 36 gallons of latex (or 1: 3,600). This should produce a satisfactory percentage of second fraction when the first clot is removed on the next day. If it is desired that the first clot be removed on the same day, it may be found advisable to increase the proportion of acid.

The first clot should be separated after formation (by stirring) by running out the second fraction from the receptacle containing it (preferably a bulking tank or Shanghai jar) through a fine sieve (60 mesh is suitable) into another vessel in which it is coagulated.

A suitable proportion of acid for the coagulation of second clot is 1: 1,200 (as in coagulation of normal standard latex). This generally produces a satisfactory coagulation in 30 to 45 minutes. If a quicker coagulation is desired the proportion of acid should be increased. The addition of further quantities of bisulphite to the second fraction is unnecessary.

Since these recommendations were drawn up it has been discovered that during the wintering season 90 per cent fractions have a tinge of yellow. Consequently, during this period it is advisable to increase the initial quantity of acid. It has been found that a suitable proportion is 1: 3,000, i. e., one gallon 1 per cent acetic to 30 gallons 2½ pounds latex. This should produce a second fraction of about 80 per cent.

The pale-colored crêpe produced by the addition of sodium bisulphite brings a premium in the market, but the quality of the crêpe is not altered, and therefore no more is made in the Goodyear Estate. Crêpe prepared without sodium bisulphite has a light brown shade.

Considerable attention has also been given to the use of para-nitro-phenol as an antiseptic for preserving smoked sheet from mould. Interesting results with this chemical were made for the writer by Mr. J. Edwards of the Federated Malay States and complete directions for its use are given hereunder:

PARA-NITRO-PHENOL

This chemical is used as a mould preventative for smoked sheet. It is somewhat troublesome to dissolve and if it is desired to incorporate it with the latex, I recommend that it be used in the form of a 1 per cent solution, the minimum proportion necessary being one volume of 1 per cent solution to 60 volumes of standard latex. It can be used with both sodium silico-fluoride and acetic acid. An alternative treatment which I am more in favour of, however, is the soaking treatment which is carried out as follows:

Dissolve approximately 3¼ ounces of the chemical in 20 gallons of water. Introduce the newly rolled sheet one by one into this solution, leave for half an hour, and then drip dry and smoke as usual. To insure thorough immersion of the sheet, the batch can be weighed down by means of a stone or other heavy weight. The chemical is shipped in drums and is in the form of a cake which contains an appreciable amount of moisture. The most convenient method of handling it is to empty out the cake into any suitable vessel (say a Shanghai jar) and leave exposed for a couple of days when it can be crushed into a powder. This quantity of solution will be found sufficient for about 50 two-pound sheets. The solution can be kept for two days and used for treating successive batches of sheets. Then it should be thrown away.

It is believed that the use of sodium silico-fluoride and the para-nitro-phenol will lead to the complete elimination of curing by smoking and the introduction of air-dried sheet.

Latex preservatives or anticoagulant.—Ammonia is commonly used. Sodium and potassium hydroxides were sometimes employed and .5 to 1.0 per cent solution will preserve the latex for 2 years. Five gallons of 20 per cent ammonia to every 100 gallons of latex was used at Kent Estate, Federated Malay States. At the Goodyear 750 pounds ammonia gas to every 3,000 pounds of water was the stock solution and 6½ pounds of this solution to 100 pounds latex. But it is better, however, to pass this quantity through ammonia gas than to use the ammonia water.

Sodium sulphite and formalin are usually used. Formalin of 2 to 3 per cent is employed as an anticoagulant and sodium sulphite of 10 per cent is used preferably than formalin.

If premature coagulation is the aim a few drops of any of the above solutions are placed in each of the collecting cups before or while tapping or the cups only dipped off in a bucket containing the anticoagulant solution.

With latex for exportation ammonia is widely used as preservative; and this process does not save any of the freight. The direct use of rubber latex particularly when concentrated by evaporation in the presence of protective colloids, or "creamed" by centrifuging, still continues to receive attention. The creaming of latex reduces transport costs, and the direct spraying of latex (as described elsewhere in this report) eliminates the use of costly coagulants and drying materials. However, to remedy the situation, i. e., so as not to send latex with its water content, the Merliman Estate has invented a method of shipping its latex in concentrated form. The process of preparation is described on pages 315 to 316 of the Indian Rubber World, Vol. LXXV, No. 6, March 1, 1927. By the addition of water it becomes fresh latex again. The concentrated latex is known as "Revertia" and it contains about 65 per cent of dry rubber and 72 per cent total solids. This is Haurser's process. The product is a paste which is retorted in half venesta tests.

Machining.—The use of power-driven machinery on large estates and hand rollers for small planters is common. The power is supplied by gas and oil engines. Adjustable hardened steel rollers set in pairs horizontally vary in type according to the product desired.

1. In sheet rubber, while one machine with plain even speed rolls could roll the coagulums to the necessary thickness, in large estates two of these machines are sufficient to save continual adjustment of the rollers and variation in thickness of the sheet. It is passed once to each of these machines and finally to the marker.

The final marking is done on a third machine, for which purpose a crêpe machine was sometimes used, after reducing the revolution of the two rollers. This is to prevent the sheets from sticking together and to accelerate drying. Smaller grooved markers and thick smoked sheets are preferable to larger grooved markers and too thin sheets. Thick sheets hide the defects easily. One-eighth of an inch thick and 18 inches long sheet is produced from a coagulating pan 4 by 10 by 16 inches.

In small estates the coagulums are kneaded by hand and rolled by a smooth hand roller to extract the water.

2. For crêpe the coagulums are rolled into strips and then macerated by passing them through crêping machine the rollers of which are deeply grooved and geared to run at different speeds so that the coagulum is macerated, then on one or two similar machines with less deeply cut rolls.

Crêpe of about one-fourth to one-half inch thick is being prepared in Ceylon as follows: After the ordinary course of coagulation, the coagulum is milled into a very thin crêpe and then dried for two days at room temperature; after this it is again remilled for a thicker crêpe, and then packed for shipment. This system of manufacturing crêpe, it is said, economizes the time of drying and instead of 8, 10, or 12 days only two days' drying is necessary because of the thinness of the rubber to be dried.

The machines are arranged in a series, and when maceration has been completed, the rubber is rolled out to make exceedingly thin sheet having a fine even texture in plain rolls in order to make it even and facilitate drying and prevent "spot" disease.

3. *Lower grades of rubber such as compo crêpe made from lump, shavings, scrap, washing, etc.*—A universal washer has been provided for this purpose. It is a machine with rollers having large excrescences or blunt teeth, and is designed to run under water. The charge is fed on by hand through a hopper. The waste, finely pulverized, is mixed with the water and washed away through a gear. The clean rubber is discharged in the form of a sausage which is suitable for treatment in the creping machine.

4. *Sprayed or desiccated rubber.*—Latex preserved in ammonia or some other suitable preservative is run into a metal disc rotating at a high rate. The peripheral force of the disc discharges the latex in the form of a spray into an atmosphere heated in a closed chamber supplied with hot air, to not more than 175° to 200° F. which converts the water into steam. Too hot air will burn the rubber and too cool will drop as latex and not perfectly dried. This vapor is carried away while the solid particles of rubber substance gravitated to the floor of the chamber in galvanized trays, like flakes of snow, from whence they are withdrawn and compressed into blocks suitable for shipment. The important feature of the process is that it gives a greater yield of rubber per gallon of latex than can be obtained from any other known process of coagulation. Economic success is dependent on the grouping together of several estates to supply the latex needed by the factory. Operated on a small scale, the cost of the machinery would be prohibitive. There is only one of these machines now in operation. It is owned by the H. A. P. M. in Sumatra and has a capacity of 2,000 pounds latex per hour for each sprayer and there are seven sprayers in this factory or 3,000,000 pounds dry rubber per month. The machinery is said to cost ₱40,200.00 each tower or sprayer, and one is under construction in Java. The cost of milling per pound is said to be 5.63 centavos, but the detailed cost is kept secret by the company. The finished product contains from one-fourth to 1 per cent water.

Sole-crêpe.—The manufacture of sole-crêpe originated in Ceylon during the war because of the difficulty in obtaining vulcanized soles for their favorite sports. At present sole-crêpe has become established in the market as a regular type. Its only drawback is the tendency to become slippery on wet asphalt and tacky in the sun. In preparing the sole-crêpe the so-called cold process is employed, and not the manufacture of a lacy crêpe by means of vacuum dryers, afterward working it up into sole-crêpe. This is made by putting together several sheets of pale crêpe as follows:

At first the latex is strained in bulk with the utmost care, then standardized at 15 per cent rubber content and during wintering its concentration is reduced to 10 per cent so that there will be less serum constituents and soft coagulum. This readily work up into a thin crêpe of uniform texture. In order to produce a good pale color 1 to 1.5 grams bisulphite is added to every liter of latex; larger doses tend to retard the rate of drying. Some estates practice fractional coagulation, which process has been described already in this report.

The milling begins in the same manner as for ordinary crêpe in the usual macerating rollers. The narrow crêpe is then remilled into a wide crêpe in the special sole-crêpe rollers, 4 to 6 breadths of crêpe being fed into these rollers. Generally the proper finishing is not attained the first time and the crêpe has to be doubled once more and then put through the fine finisher. The sole-crêpe should be even and of uniform texture. The moist wide crêpe is then cut into the required dimensions, providing of course for the shrinkage.

After the crêpe has been dried for about five days the making of sole-crêpe is commenced as follows: In a clean room with cotton cloth ceiling the layers are stuck together by being pressed close and all possible dirt is excluded from the working room and crêpe sheets during the early morning or in damp weather. Four or more sheets are stuck together depending of course on the thickness of the sole-crêpe to be made. Usually 4 layers make one-eighth of an inch of sole-crêpe. At first two pieces of the fine crêpe are accurately laid one on top of the other above the table where they are being pressed lightly by hands. Hand pressing is preferable to the wooden pin since it prevents air bubbles inside. After two sheets have been joined in this way another is stretched out on them and treated in a similar manner and so on until the required thickness is secured. This thick sheet is now ready for lamination. However, if a sufficient width of crêpe is not obtainable first two narrow crêpes with the edges trimmed off are put together, then cutting them together with an ordinary scissors, these two crêpes are automatically joined.

Lamination.—The sheets are first slightly warmed on spiral hot water table. The top of the table is a flat zinc tank through which hot water of 45° to 50° C. circulates. Light cotton blankets are spread on top of the zinc in order to produce an even heat. In some factories warming is done while machining. Each side of the sheet is heated not longer than two minutes, otherwise a soft and dark sole-crêpe is produced by over heating. Covers are spread on the blankets in order to prevent the dirt and the bits of fluff from sticking to the crêpe. Warm water is dispensed with during hot days and in hot parts of the factory.

After being heated the sheets are passed through the laminating rollers not more than three times with a speed of 10 to 15 revolutions per minute. Excessive rolling gives a dark and translucent sole-crêpe. The sheets are then heaped in high piles and allowed to remain for 24 hours, to cool and settle. The wrinkled edges are thereby flattened out. These are cut into the desired size, say 13 by 36 by $\frac{1}{4}$ inches. The well-known wet knife appears to give the best results. It is an apparatus similar to a press in appearance outside but it is provided with sharp steel edges for cutting. The ordinary 18-inch smooth rollers should be fitted with equal gear pinions or revolved by friction only.

Sole-crêpe with one smooth and one rough side is built in different ways, that is, the first, a combination of one smooth and one horizontally grooved roller, is employed and followed by two smooth rollers.

Sheets with wrinkles, air-bubbles, dirt, discoloration, etc., should be sorted out properly. Finally the sheet is sorted according to its color. All rejected sole-crêpe together with the trimmings produced by cutting the edges are made into crêpe again, then into sole-crêpe as previously described.

Drying.—Precautions are taken to dry the rubber properly in order to prevent the growth of fungus on the smoked sheets, crêpe, slab, etc.

1. *Smoked sheets.*—After the sheets have been thoroughly washed the extra water is allowed to drip off by hanging the sheets for an hour or two either at room temperature or in the sun. Washing in slightly warm water will facilitate smoking and give better colored sheet. Then they are taken into the smoke-house for a complete drying in an atmosphere with a regulated temperature for several days or weeks as the case may be. Drying them at 50° C. for 36 hours in a small smoke-house first then transferring them to another smokehouse to completely dry them in 10 days is done. In the first smoke-house the pins are turned every ten minutes and once a day in the second one. Usually it takes one to two weeks in the smoke-house by smoking day and night and by turning the pins properly

and by opening the windows from 7 to 10 a. m. in order to insure even drying.

There are several kinds and sizes of smokehouses in use. Some have the stoves placed outside the building while others inside and the smoke is led to the center by a flue. They are constructed of different materials, such as bricks, cement, etc., and have iron or wooden walls and iron roofing, but the small planter uses a smokehouse made only of clay soil with bamboo or wood reinforcement. Whatever may be their construction in the future they will have openings for the entrance of fresh air both at the top and the bottom. They are one or two-story buildings besides the ground floor for the stoves or smokes.

In the Federated Malay States, the "Davon" smokehouse is now becoming popular. It is a two-story building, with the stovess placed on the outside on a concrete base. Through the middle of the building there is a passage and each story has four rooms, each with two trucks where the rubber sheets are hung. The trucks travel to the ground floor by rails and cables in the packing house. This house has a total capacity of about 5,120 sheets. It takes from 8 to 10 days to dry rubber perfectly at a temperature of 120° F. in the smokehouse. In a properly constructed smokehouse it takes only five days to dry it.

In a smokehouse having a capacity of 6,500 kilos a day they consume three bullock carts of firewood. Where to get firewood is now one of the problems confronting Malaya in the manufacture of rubber. Some planters have planted forest trees for firewood while others have no place for such, and this leads to the use of chemicals to prevent the attack of fungus in air-dried sheets.

The poles on which the rubber sheets are hung are placed far apart so that in turning the pins the sheets will not touch each other. A distance of 2½ feet is found sufficient for the standard sheets.

A perfectly dried sheet has no white appearance inside. By cutting a bit off each corner its condition can be seen.

2. *Crêpe.*—Crêpe analyzing between 0.40 or 0.65 per cent moisture is considered normal. The first latex crêpe will be air-dried in about two weeks if rolled sufficiently thin and smooth and if the drying house is good. The windows of the drying house are opened during dry windy days. The drying house for crêpe is usually a two-story building and the ground floor is used for packing the rubber. Crêpe is dried either in hot air or at room temperature.

3. *Slab.*—Latex coagulated and allowed to dry in the air as crêpe without machining is called slab. This usually takes longer to dry because of its thickness, and because it contains about 20 per cent moisture and has a dirty brown leathery appearance. It can be made into crêpe by machinery. It takes about 10 days to dry at room temperature before it is packed for shipment.

Vulcanization.—Rubber samples produced from different estates are sometimes submitted for a vulcanization test at the Kuala Lumpur Department of Agriculture, F. M. S., and at the Rubber Central Stations in Java and Ceylon, both of which institutions are provided with a small vulcanizing machine such as the mixing and the calendaring machine, besides an apparatus for testing the strength of the rubber. The work is done as follows:

1. The rubber to be vulcanized is dusted with flowers of sulphur after it is kneaded through hot rolls and brought into a plastic condition. In the Federated Malay States and Ceylon 10 parts of sulphur for every 90 parts of rubber is mixed and in Java 7½ sulphur for every 92½ rubber while it is being rolled in the mixing machine. The mixing machine is regulated by its girth and provided with cold and warm water pipes inside the rollers, so as to keep the rollers warm while mixing the rubber. The temperature of the rollers is kept at 60° C. or so warm that one can just touch them with his hands.

Lime, magnesia, zinc oxide, etc., will facilitate vulcanization and the 10 per cent sulphur, it is said, so that it will take only 3 hours for the ordinary sheets and crêpe rubber and 1½ hours for the slab to vulcanize. If warmer than this it will make the rubber sticky and if too cool it will take longer time or it will not mix with the sulphur at all and besides it will not kill the cells of the rubber. It has been observed that soft rubber will take shorter time to mix than hard rubber.

2. After being properly mixed the rubber is rolled in a canvass and is then passed at once through the three-roll calendaring machine to make it uniform in thickness—about 6 millimeters. This is done to obtain a better distribution of the sulphur.

3. The sulphurated rubber after the necessary mixing and calendaring is pressed in between two steel plates in a rectangular form and then put inside the autoclave having an inside temperature of 140 to 150° C. for about 55 to 130 minutes at four atmospheric or 38 to 50 pounds pressure. The amount

of mineral added in the rubber will determine the time in the autoclave.

4. The rubber is then dusted with talcum powder so as not to be too sticky to handle, then it is ready for testing its tensile strength and this is done as follows:

a. Cut the rings in a circular cutting machine for about 4½ centimeters inside diameter and 3½ millimeters thick. The outer diameter of the ring is about 5.2 centimeters. In making the ring, the first and the last cuts are to be discarded and the middle portion used for the testing.

b. The average thickness of the ring is measured with the use of an automatic micrometer. Then it is placed in a Schopper testing machine for its tensile strength. A curve is automatically drawn while the machine expands and this indicates the relationship of the length and the width or its steepness and elasticity. This machine is regulated by a hydraulic ram piston which pulls the ring of the rubber out. During the stretching the machine automatically registers the course of the process when at last the ring breaks.

The readings are taken as follows:

1. Thickness in millimeters.
2. Load means the breaking load.
3. Load per square millimeter.
4. Elongation at breaking point the reading at 100 standard.
5. Multiplying the elongation of break by the load per square millimeter will give the index of the quality of the rubber.

If the ring goes out beyond the capacity of the testing machine it is said that it is under cured and if below too long cured.

Viscocity test.—Rubber and benzine in the proportion of about 1 to 100 grams are mixed together and the mixture is allowed to stand in darkness for two to three days,[1] after which it is filtered off, but to be more exact it is sometimes made dry by distilling off the benzine. Place the rubber after adding the pure benzine in the viscocimeter then test the time of the pure benzine and the solution of rubber. But both have to be kept exactly at 30° C. The smallest changes that can be obtained indicate a first quality rubber. For old rubber a ratio of one of benzine to 28 to 42 of the rubber is found and for young rubber 20 to 25 and for inferior quality it is still lower, while tacky or oxidized rubber has 5 to 6.

Climate, much acid, too long or too short drying and changing of the method of manufacture, etc., influence the viscocity of the rubber.

Plasticity test.—About 0.4 gram rubber is made up into a ball-like mass then it is placed on a steel plate (William apparatus) and kept at 80 to 100° C. in 45 minutes but 30 minutes is the standard. Its thickness is measured then by the micrometer. It is said that the thickness of rubber after 30 minutes will be between 1.35 and 1.70 for crêpe and 1.3 and 1.60 for sheet.

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[1] Light is kept out because it oxidates the rubber molecules.

Factory.—Coagulating and machining are done in another building away from the smokehouse and constructed in different ways and of various materials, but the drying house for crêpe is usually connected with the factory.

Packing.—The sole-crêpe is packed in special cases of strong wood, the inside of which is lined with paper to protect the rubber from fibres and infiltration of dirt. The sole-crêpes are laid flat and not pressed. In nailing up the boxes care is taken not to allow the nails to penetrate into the rubber. Usually 150 to 200 pounds are packed in a case with the company's brand outside the box. Many times excellent rubber has been seriously damaged by packing it in wet boxes or in cases in which all the woods were not thoroughly dry.

The majority of the planters pack the rubber smoked sheets and the crêpe in veneered cases and the lower grades of rubber in roughly and locally made boxes of varying weights. Some weigh from 130 to 140 pounds each, while others 224 pounds to the case in gross weight. The Goodyear Rubber Company and the Tan Kah Kee both pack their rubber for shipment in gunny sacks and mats made out of pandan. By this system, instead of 170 pounds to the box in the case of crêpe they pack 200 pounds and 260 pounds for the smoked sheets, which appears smaller in dimensions than the box holding lesser quantity. The bale is usually 24 by 24 by 18 inches. This packing eliminates the cost of ₱1.42 for the veneered case and 4 centavos for assembling it. Rubber is pressed before packing. It spreads singly at the bottom and above it, after pressing. This is to cover around the baled rubber before the sack is put on. In the Goodyear and Tan Kah Kee plants, the pressed rubber is dusted over with talc powder around the bale before it is wrapped in a sack or mat to keep the fiber of the sack from sticking into the rubber and to prevent the dust from sticking to it. While still in press crêpe rubber is temporarily held by rattan, which is removed while sewing the sack or mat. In well-managed estates rubber is sorted before being packed and all defects and dirt removed.

Sprayed rubber is also packed in bales of 200 pounds each at the H. A. P. M., Sumatra.

The expenditure per bale is said to be about 12 centavos including the delivery to the steamer from the warehouse at the Goodyear Company at Ceylon.

With five presses and five laborers working they can finish pressing about 100 bales a day at the rate of from ₱0.88 to ₱1.04 for each laborer.

For sewing the sack a woman receiving about 40 to 44 centavos a day can finished 30 bales. The sacks cost about 5.6 centavos each and the twine about 0.4 centavos. Loading is about 5.6 centavos a bale. In this way the cost of the case has been eliminated, which is said to be about ₱1.28 a case for Japanese make and ₱2.00 each for a veneer box.

Storing.—Boxes or bales of rubber are not allowed to stand direct on cemented or dirt floor of a warehouse as the rubber would get mouldy. Under the boxes or bales they put pieces of wood or bamboo so the air can circulate beneath.

MARKETING

The decline in price during 1920–1921 was said to be due to overproduction, accumulation of stocks of manufactured articles, general trade depression and world-wide financial difficulties. Crêpe was 4.86 centavos and ribbed sheet 4.18 centavos per pound up to the middle of 1921. The severe slump took place in 1920–1921 and the industry revived in 1924–1925 as the result of the restriction. The rubber boom was caused by the restriction scheme, mainly, but increased consumption, the continuous fall in stocks and the operations of speculators contributed to a certain extent. When the restriction went into effect the price rose at once from ₱0.365 to ₱0.649 per pound and since that date the price has remained at a steady rate of about ₱0.608 per pound. Various forecasts have been made regarding the rubber position and a deficit in the supplies is prophesied by some and an excess is prophesied by others. The producers fear that a decreased demand for rubber in some directions will soon be experienced because of the use of reclaimed rubber, the increase of native rubber and the possible overplanting of fresh areas and the increasing production of the already tappable areas. And they are not forgetting that every "boom" is sooner or later followed by a "slump." But consumers have a different view on the subject, and with their conservative estimate of only 5 per cent increase in consumption yearly at least 203,000 acres are to be planted yearly with rubber to meet the world demand besides the existing areas under cultivation. It is said that during previous years the increase in rubber consumption was about 10 per cent.

The Stevenson Act.—Standard production is the quantity of dry rubber produced from any holding that has been specified or assessed by the Government. Any rubber above the permitted amount is subject to a heavy tax.

1. There is an export duty on rubber produced in all British possessions, particularly Malaya and Ceylon, except Singapore, Penang, India, and Burma. The first two mentioned places are exempted to maintain them as free ports. However, the amount of rubber produced in these places is practically negligible and, besides, the plantations practically are about all owned by the British. Because of the last reason and to comply with the scheme, the planters have made a sort of a gentleman's agreement.

2. The Stevenson Act originated from the petition made by the planters so that when the British government recommended it to the government in Malaya and Ceylon, it was once approved without practically any alteration.

3. The duty put on this assessed production was too small, say 2.26 to 3.39 centavos per pound. This will not prevent the exportation of rubber. The duty before the act came into effect was less than one-fourth of a centavo per pound. The 2.26 centavos duty paid for the execution of the scheme. Now in order to prevent the exportation of rubber they put a very high duty for the rubber exported by each estate above its assessed production, a duty that will not even pay the cost of production.

4. The basis of estimate is as follows:

(*a*) The productive capacity of the estates before the law went into effect. To get this, first, the Government sent a form to be filled by the different planters stating in a sworn statement their maximum productive capacity.

(*b*) The normal production was also considered in the different estates.

(*c*) The production per hectare of the different ages of the plantations—from 5 years, 6 years, 7 years, 8 years, and so on. From 5 years the yield was considered rising up to 15 years then going down, depending of course upon the soil and climatic conditions of the estate.

(*d*) Assessors went around in the different estates and native planters and assessed the different plantations fixing the amount each was entitled to export from his estate.

(*e*) They considered ₱0.608 as a fair price and took that as a base.

5. It was arranged on a sliding scale. Started at 60 per cent when the price was below 1s per pound; when rose to 1s and 6

pence during the quarter the production was increased to 65 per cent and above this price to 70 per cent and so on. When prices went down it was reduced to 5 per cent and so on.

6. All the producers were given certificates indicating how much they are allowed to export or sell. No bill of lading is issued unless they reproduce the certificate and the customs officers were instructed not to give clearance without seeing the certificates. Duty charged on the allowed exportation was almost negligible but if there was an excess a charge was made that made impossible to sell without a loss. In 1925 the large holdings were assessed from 400 to 500 pounds per acre, and small holdings not more than 25 acres from 320 to 400 pounds.

7. The certificates were issued quarterly.

8. The commissioners were given the right to reassess the producers in favor of the estate if the latter had been improved and there were sufficient reasons and to lower it in case it was too highly assessed.

9. The Dutch did not follow this scheme but instead sold the products at 100 per cent and made profit. However, the plantations on the east coast of Sumatra are practically controlled by British capitalists, for which reason the restriction was voluntary.

10. No restriction since February 1926, because the price went above the standard (1s and three pence). However, with the lowering of price again, they are thinking of putting restriction into effect once more. It also serves as a good basis for revaluation under present conditions on the estates.

In sending latex for exportation the government considers that every gallon of latex contains 3½ pounds of dry rubber. The benefits derived by the planters in exporting latex are the duty and the restriction output, because a gallon of latex in most cases, especially from old trees, contains more than 3½ pounds dry rubber. Therefore, the duty levied is only for 3½ pounds and the restriction has to be based on this amount too. From young trees they obtain only 2½ pounds and from old trees as much as five pounds per gallon of latex.

Rubber smuggling often occurs as the results of the restriction in British Malaya and heavy fines are imposed on the smugglers. When the writer was in Singapore two Chinese were fined ₱4.181 each or in default 6 months' imprisonment for smuggling only 14 piculs and 3.5 "katis" rubber shipped without the necessary clearance. And in another similar case after the conviction in the former case, three natives were fined ₱5,084.46 each or in default 6 months' imprisonment for smuggling only 17 piculs and 44 "katis" of rubber.

Some of the planters consider the assessment liberal while others complain of their low assessed production. The marginal limit for assessment of standard production in the case of small holdings was raised to 400 pounds per acre for mature rubber and 200 pounds for rubber in bearing but not mature. And the 500 pounds per acre provided for under the former regulations applicable to assessment of estates of more than 25 acres in Malaya was abolished.

In Malaya and Ceylon no rubber is exported in excess allowed by coupon or other document or unless with the written permission by the Colonial Secretary and upon payment of 47.46 centavos duty per pound. Burma and India are not included in the restriction scheme since they only produce a very small percentage of the world supply. In Burma, however, under the Burma Forest Regulations a royalty is levied on rubber of 2 per cent on the net value, which is calculated each month on the average London market rate for standard or first latex crêpe and sheet rubber for the previous month with a deduction of 9.12 centavos a pound as an allowance for the proportion of lower grade rubber and with a further reduction of 97.32 centavos a pound for the cost of production, freight, and sales charges. If the London rate is less than 100.36 centavos no royalty is levied. The royalty is paid only on the amount in excess of this rate.

Marketing.—At Rangoon recently an attempt was made by one of the firms there to establish a rubber sales center in that city but considerable difficulty was encountered in the development of a Rangoon market, chief among which is the higher costs of bringing rubber from the southern part of Burma than to tranship it to Singapore. The prices realized at the two sales thus far held in Rangoon were equivalent to the prevailing price in the London market, less shipping costs. With what success this market will be developed remains to be seen at present. Practically all the sales are made in London or Singapore. However, in Singapore as well as in Penang a central rubber market has been functioning successfully for years now and it is carried as follows:

1. Of all of the rubber sent to Singapore very little is sold through public auction, they said.

2. The auction is run as follows:

a. There are at present more or less 12 or 14 firms who participate in the auction such as Harrison, Volstead Borlow, Louisfit, Guthrie, Hooglandt, Patterson, Simmons, Walter House, Sime Darby, et al.

b. To be admitted as member you have to sell rubber not less than 600 pounds.

c. The aforementioned firms are both brokers and estate agents.

d. The planters send their rubber to their estate rubber agents. The representatives, in turn, store the rubber in their go-down (warehouse). Then they inspect and draw 3–7 sheet samples. These samples are listed and catalogued, then fastened together by a sealed clip and have a number marked on the tag and placed side by side, on long desks.

e. The buyers and the agent are both provided with the respective catalogues issued once or twice a week.

f. The samples are sent to the Chamber of Commerce for award and for display in the auction building so that the buyers may examine them previous to the auction which is held every Tuesday and Friday. During the forenoon members of the Standard Qualities Committee go around, alone or with other members, and carefully examine each sheet and sample. The catalogues are marked "yes" or "no" after determining the samples. At midday the notes are examined and, in case of doubtful samples, the chairman gives his decision.

g. The catalogues are then used as their guide in buying the rubber. The buyers mark the corresponding grades in their catalogues as they examine the samples.

h. The committee set award to all rubber samples meeting the standard grade and seal them. Not all samples displayed are given award, but rejected grades are sometimes sold at the same price as the awarded standard grade. Sample which is clean both inside and on the surface and properly cured and dried show no sign of fungi or mould or not excessively rusty, and is not short or brittle when stretched is considered to have fulfilled the requirement for an award. Color, shape, size, were of minor importance. Impurities, such as sand and bark shaving, are commonly found.

i. The Chamber of Commerce has the following grades only:

1. Two grades at top. (*a*) Ribbed smoked sheet containing only one-half per cent moisture and more dandy. (*b*) Pale crêpe, must be clean and not mouldy or dirty.
2. Blanket crêpe made from native rubber produced in Djambi, Palembang, Pontianak, Bandjermasin, Tapanoeli, and other small ports of Borneo and Sumatra. This rubber comes under four grades, namely:
    a. Light amber color.
    b. Medium light amber color.
    c. Dark amber color.
    d. Very dark, almost black, amber color.

j. Those samples that do not pass the above grades go under miscellaneous grades and are sold in samples.

k. Another grade that sells in samples are the scraps and shavings which are washed up and made into brown crêpe.

l. The prices of the aforementioned native rubber are as follows:

(*a*) Eighty per cent of Nos. 2 and 3 are sold together at certain price, say from 2 to 15 Straits cents below the smoked sheet grade.

(*b*) No. 1 depending upon the demand or 2 and 3 Straits cents above Nos. 2 and 3.

(*c*) No. 3 is sold 2 to 3 Straits cents below Nos. 2 and 3.

m. In order to pass award to the submitted samples of native rubber it must be firm and strong in any of the four kinds, and not soft, tacky, dirty or adulterated. If so it goes to lower grade.

n. The auctioneer has to set the price if there are no anxious buyers but in most cases the buyers have to do it.

o. Rubber samples not sold are brought to the different offices of the buyers by the middle-men and they try to sell at a low cost and if they still are not sold they are again included in the next auction or returned to the owners if again are not disposed of.

p. Most of the rubber produced in the British colonies is sold in London and only a little is sold locally. Many of the sellers do not sell locally but insist on selling in London because many of the stock holders are in London.

q. About three-fourths of the rubber in London goes to the United States and most of the time the London people never even see it but only the bill of lading for indorsement. Some is sent from Malaya ports direct to the United States at the request of the London agents, and sometimes while the rubber is on its way to London orders are issued to deliver it to the bearer in New York, as arranged by the London agents with the buyer's agents.

YIELD

The normal life of the Para rubber tree has so far not yet been determined. All the cultivated trees are yet too young to judge the productive life of the tree. In Java, some came to the conclusion and published it that 30 years is the normal life period of a rubber tree. However, evidence disproves this theory. In Burma, for instance, a rubber tree 48-year old is said to be better than any trees from younger areas on the same estate. In Buitenzorg, Java, two of the first trees planted in 1882 are still standing in the garden and now are about 30 meters high and 2.84 meters in diameter 1 meter from the ground.

Of the trees said to have been planted from seeds of the 1882 trees at the Buitenzorg Experimental Garden, there are about 14 trees living. In 1925 these trees had an average circumference of 147 to 225 centimeters one meter from the ground. These trees are now being tapped at a height of about 60 centimeters from the base on 1 cut one-fourth circumference alternate days and 1.8 to 2 millimeters monthly bark consumption. The yields of dry rubber in grams once a week for one day in 1926 were as follows:

Tree No.	June 5, 1926	June 11, 1926	June 19, 1926	June 27, 1926
1	25.2	35.5	27.1	33.5
2	50.6	40.8	41.3	35.1
3	77.9	73.7	57.5	76.4
6	31.1	9.5	27.0	28.5
8	15.9	19.5	24.1	24.7
9	62.2	63.5	68.8	72.3
11	18.3	14.3	16.5	22.5
14	18.1	18.6	14.8	16.4
18	45.4	42.0	44.8	43.3
19	38.4	44.6	41.7	46.0
20	19.9	20.3	21.4	25.3
24	32.8	36.7	37.2	41.3
28	37.7	45.0	42.6	39.0
29	9.0	11.9	9.3	12.3
Total	572.5	485.9	474.1	516.6

In Java the best production is attained during the months of December, April, and March, and lower yields occur in August and July, while during the month of June a fairly good yield is obtained. Taking 150 as the number of tapping days in a year and since a tree produces an average yield of 39.59 grams per tapping, then the production of that 44-year old tree will be approximately equal to 5.49 kilos of dry rubber a year.

At Heneratgoda Experiment Station trees planted in 1877 produced an average of about 12 pounds per tree for 3½ months in 1913, or when they were about 36 years old, tapped daily in the 3V's system. And those planted in 1886 produced from 7.8 to 12 pounds when they were 27 years old and 3½ months.

In Kuala Lumpur, F. M. S., trees planted in 1898, 48 out of the 65 trees yielded 412 pounds of No. 1 rubber to the acre in 1923. In May, 1925, these trees had an average girth of 55 inches. The yield of the 27-year old trees in that country is satisfactory also, as it works out at 558 pounds of No. 1 rubber per acre per year.

The foregoing yields indicate that the yield increases as the tree gets old and how far this will go till the tree ceases to produce economically nobody knows just at present since the plantations in Malaya, Sumatra, Java, and elsewhere as stated before are yet not sufficiently old to determine the life of the tree. The economic life of the tree depends upon many factors as follows:

1. Soil erosion.
2. Severity and quality of tapping.
3. Bad soil moisture.
4. Diseases and pests.
5. Impoverished soil.
6. Introduction to new regions.
7. Planting condition—distance, drainage, etc.
8. Past treatment of the tree as regards tapping and pruning.

The yield generally varies with the soil, age, rainfall, drainage, planting, disease treatment, etc. And the actual yields from the different rubber-growing countries are tabulated below.

In Malaya it has been observed that:

1. The best yield is obtained from October to February. The crop during the wintering season decreases to a greater extent on flat land than on undulated land.
2. The crops fall off from March and till the fresh leaves are put on which is in June.
3. Best yielding month is December. April is the poorest, and normal yield occurs in May.
4. There is less falling off in yield due to wintering in alternate-day tapping as compared with daily tapping.
5. Crops fall away, owing to wintering from the middle of February till March. Two or three weeks later they increase slightly.

In Malaya, Ceylon, Sumatra, Burma, and Java, it is estimated that the yields at different ages are as follows:

Age (years)	Yield of dry rubber in pounds and grams						
	Ceylon		Malaya		Sumatra	Burma	Java
	Per tree	Per acre	Per tree	Per acre	Per acre	Per acre	Per tapping per tree
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Grams*
3- 4	0.75	90	.53-1.06	50-100	24- 90	....	....
4- 5	1.00	120	.88-1.50	70-136	90-160	....	....
5- 6	2.00	240	1.21-1.71	114-160	160-250	75	....
6- 7	3.00	360	1.60-2.47	128-221	250-390	120	5
7- 8	4.50	540	2.44-3.39	240-319	390-460	150	8- 9
8- 9	6.00	720	3.09-4.17	313-443	460	200	10-12
9-10	7.00	840	3.90-4.45	363-550	....	300	14-16
10-11	....	....	4.77-5.35	396-630	....	....	20
11-12	....	....	5.69-6.76	450-758	....	....	25

Yield record of trees at different ages planted 1906 in Ceylon

Year	Block I					Block II			
	Area (A)	Number of trees per acre	Yield of dry rubber in pounds			Area (A)	Yield of dry rubber in pounds		
			Total		Per acre		Total		Per acre
			First grade	Scrap			First grade	Scrap	
1913	54	75	4,282	720	92	45	6,507	1,405	172
1914	54	75	10,895	1,791	235	45	9,462	2,350	254
1915	54	75	14,551	2,184	276	45	13,233	2,346	368
1916	54	75	18,389	2,763	322	45	13,713	2,273	355
1917	54	75	19,774	3,042	345	45	14,872	2,185	379
1918	54	75	4,145	968	79	45	7,834	2,284	338
1919	54	75	23,876	3,877	420	45	17,372	3,315	459
1920	54	75	20,988	3,978	379	45	17,227	4,101	473
1921	54	75	18,990	....	290	45	16,209	....	373
1922	54	75	21,088	2,776	361	45	15,169	2,076	383
1923	54	75	14,202	1,225	342	45	11,797	1,621	268
1924	54	75	14,197	1,459	347	45	10,349	1,270	231
1925	54	75	14,278	1,512	351	45	12,440	1,488	277
1926 (9 months)	54	75	10,354	1,056	253	45	10,037	1,631	233

Block I.—In 1918 not all the trees were tapped till December. In 1921 the scrap was not collected. In 1923 the trees were not all tapped again. In 1924–1926 some of the trees were rested because of diseases and they were tapped daily every three days beginning 1925.

Yield record of trees at different ages in Ceylon

Year	Date of planting	Area in acre	Average number of trees per acre	Yield in pounds of dry rubber			Remarks
				Total	Per acre	Cost of production per pound (C. R. S.)	
1913	1906	310	75	52,643	120	1.13	Alternate day, January–July, 1913.
1914	1906	......	......	111,868	242	1.00	Alternate day, January–December.
1915	1906–07	483	75	138,758	287	1.00	Do.
1916	1906–07	502	84	168,344	335	.90	Do.
1917	1906–07	502	84	188,801	376	.90	Do.
1918	1906–07	385	84	154,812	378	.90	Not all tapped.
1919	1906–07 1908–09 1908–11	502	84	228,140	454	.75	Alternate day tapping.
1920	1908–11	520	96	219,668	421	.75	Alternate day and 3 days alternate.
1921	1908–11	520	96	183,015	351	.75	Do.
1922	1908–11	520	96	198,389	381	.75	Do.
1923	1908–11	501	100	162,838	325	.75	Do.
1924	1908–11	501	100	141,585	281	.75	Do.
1925	1908–11	501	100	162,260	298	.75	Tapped alternate day.
1926 (9 months)	1906–07 1908–09 1911–17	567	94	129,595	228	.75	Do.

A tree 12 years old in Ceylon gave about 10 pounds of dry rubber per year, while the average trees yielded only from four to five pounds per annum.

Yield record of trees at different ages planted 1906–1907 in Indo-China

Year	Area in acre	Number of trees tapped	Yield in pounds	
			Total	Per acre
1911	14.83	600	484	32.63
1912	202.04	12,500	13,200	65.33
1913	242.16	18,000	35,200	145.36
1914	242.16	26,500	61,600	254.37
1915	313.82	35,500	83,600	266.39
1916	358.30	44,400	114,400	319.28
1917	358.30	48,700	144,100	402.18
1918	358.30	48,900	124,300	346.91
1919	358.30	46,400	80,960	225.95
1920	358.30	40,300	123,640	345.07
1921	358.30	36,700	135,300	377.61
1922	358.30	35,300	135,080	377.00
1923	358.30	33,800	193,600	540.32
1924	358.30	33,800	189,200	528.04
1925	358.30	33,700	149,380	416.91

Production of trees at different ages in Sumatra-Estate I

Years	Age in years	Yield per acre in pounds of dry rubber						
		White soil	Red soil					
			120 trees per acre		200 trees per acre		400 trees per acre	150 trees per acre
			Budded and not selected	Selected seedling	Budded and selected seedling alternate row	Seedling	Seedling	Budded with proved strains
1918 (6 months)	4.5	43	....	....	....	....	....	....
1919	4.5- 5.5	184	150	125	200	175	200	250
1920	5.5- 6.5	243	400	350	450	450	500	600
1921	6.5- 7.5	304	500	400	550	500	600	700
1922	7.5- 8.5	363	600	450	650	550	700	850
1923	8.5- 9.5	362	700	550	750	600	700	1,000
1924	9.5-10.5	420	700	550	750	600	700	1,000
1925	10.5-11.5	432	....	....	....	....	....	....

The plants on white soil were not selected but instead they were fertilized in 1924.

Yield record of trees of different ages in Sumatra-Estate II

Year planted	Yield per tree per year in grams of dry rubber								
	1918	1919	1920	1921	1922	1923	1924	1925	1926
1910-11	64.6	86.8	89.9	103.8	115.0	68.8	115.9	131.2	[a]54.3
1912	....	[g]36.0	81.2	90.6	66.5	51.3	60.0	63.0	[a]21.7
1913	....	[e]35.8	57.6	77.0	78.4	83.4	73.5	88.7	[a]38.0
1915-A	....	....	[b]39.9	56.0	57.8	61.3	79.4	96.9	[a]42.2
1915-B	....	....	[b]38.7	54.4	56.3	38.9	42.1	87.6	[a]39.4
1916-A	....	....	....	[b]34.1	55.6	71.0	30.3	[f]61.3	[a]41.9
1916-B	....	....	....	[d]6.7	48.2	55.5			
1917-18	....	....	....	[c]1.6	20.1	25.2	35.8	23.3	[a]6.9
1918	....	....	....	....	[b]16.9	23.8	....	19.7	[a]10.1
1920	....	....	....	....	....	....	....	28.7	[a]21.2
1922	....	....	....	....	....	....	....	....	[a]6.2

[a] Five months.
[b] Eleven months.
[c] One month.
[d] Two months.
[e] Eight months.
[f] Nine months.
[g] Six months.

Note.—From July, 1922, the trees planted in 1912, 1917–1918 and 1918 instead of the daily tapping on one-third circumference were tapped in alternate months on one-half circumference as also part of the trees planted in 1913 and 1915. Again in 1924, the trees planted in 1912, 1916, and part of the 1915 planting were tapped in two alternate months. All the rest of the tapping was done daily on one-third circumference.

Yield record of trees at different ages in Java

Date of planting	Yield per acre in pounds of dry rubber					
	1920	1921	1922	1923	1924	1925
1901	316.10	208.06	600.45	237.10	608.60	427.53
1903	222.31	414.52	600.45	247.34	173.86	191.84
1904	254.82	172.26	194.34	698.92	506.00	483.64
1907	249.53	185.97	248.14	170.21	405.70	367.23
1908	360.90	176.21	239.41	416.30	391.72	234.92
1911	288.85	233.62	311.38	347.63	454.42	474.73
1912	215.36	219.19	268.54	322.96	397.15	397.87
1913	146.60	242.80	341.62	388.84	391.05	397.51
1914	31.08	280.30	319.31	346.29	410.78	404.46
1915	....	240.23	270.77	358.23	255.71	307.46
1916	....	39.54	139.02	322.96	374.13	373.19

Yield record on different soils at the H. A. P. M.

Division	Age		Soil type	Yield per acre of first latex and lump		
	1919	1921		1919	1920	1921
	Years	*Years*		*Pounds*	*Pounds*	*Pounds*
1	7.5 8.5	10.5	Red	417	455	
2	7–8	10	do	462		
3	6.5 7.5	9.5	Good flat	365	333	
4	6.5 7.5	9.5	Loam	306	288	
5	7.5 8.5	10.5	White loam	326		
6	7.5 8.5	10.5	do	319	272	
7	7.5 8.5	10.5	do	303	348	238
8		10.5	do	376	486	368
9		7	do	211	260	302
10	7.5 8.5	10.5	(a)	383	336	
11	8.5 9.5	11.5	(a)	247	229	
12	8–9	11	(a)	293	320	181
13	8.5 9.5	11.5	Cement soil	238	245	
14	7.5 8.5	10.5	do	222		

[a] Heavy clay or loamy with impervious soil.

Summary of above table

Soil type	Yield per acre of first latex and lump	Yield per acre of all grades
	Pounds	*Pounds*
Red hill sod	450	513
Serbagan loam	400	456
White loam	350	399
White clay loam	300	342
Cement soil	200	228
Permatang (white clay)	150	171
Average for H. A. P. M	348	397

In Burma the average yield per acre is said to be from 270 to 400 pounds. However, the largest single producer of rubber in Burma, with an area of 2,243 acres under production, yielded the following:

Year	Total	Per acre
	Pounds	*Pounds*
1921	341,893	153
1922	451,826	201
1923	90,420	40
1924	715,161	319
1925	753,226	336
1926 (7 months only)	383,572	171
Total or average	2,736,098	206

In 1925 various estates in Malaya yielded per acre of dry rubber in pounds as follows:

541 in Kinta Kellas.
555 in Kota Tinggi.
200 in Cicely—22-year old.
400 in Gloucester Division.
450 in Kampar Estate.
300 in Cicely—18- to 20-year old.

In Ceylon a yield from 150 to 700 pounds per acre has been reported, and 400 to 500 pounds is considered a good all-around yield. However, in Estate I, Ceylon, the following yields were obtained from 418 acres of 15-year old trees distanced 9 by 18 feet apart and planted in very stony land.

Month (1926)	Yield of dry rubber		
	First latex	Scrap	Total
	Pounds	*Pounds*	*Pounds*
January	1,457.50	2,492.75	3,950.25
February	9,455.25	1,670.00	11,125.25
March	(a)	(a)	(a)
April	7,516.00	2,006.00	9,522.00
May	10,154.25	1,817.00	11,971.25
June	12,886.00	3,090.00	15,976.00
July	9,949.50	2,091.75	12,041.25
August	15,910.50	1,751.00	17,661.50
September	13,712.75	2,379.00	16,091.75
Total	81,041.75	17,297.5	98,339.25

[a] Wintering and no tapping.

An average yield of about 235 pounds per acre for eight months' tapping.

The average yield in Estate II, Ceylon, is about 480 pounds per acre.

In Estate I in Java, the following yields were obtained:

Year	Area in production	Number of trees tapped daily	Yield	
			Total	Per acre
	Acres		*Pounds*	*Pounds*
1915	249.57	....	15,906.0	63.73
1916	573.27	68,360	108,625.0	189.48
1917	790.72	67,260	234,691.6	296.80
1918	803.08	56,300	242,649.0	302.14
1919	803.08	63,810	211,360.6	263.18
1920	803.08	58,535	260,876.0	324.84
1921	803.08	56,707	173,361.0	215.87
1922	803.08	56,707	324,570.4	404.15
1923	803.08	56,693	358,041.2	445.83
1924	803.08	55,575	356,714.6	444.18
1925	803.08	55,612	409,640.0	510.08
Total or average	8,038.20	595,559	2,696,435.4	335.45

The average yield per acre for 11 years is 335.45 pounds. In Estate II in Java, the following yields were obtained:

Year	Area in production	Number of trees tapped daily	Yield	
			Total	Per acre
	Acres		*Pounds*	*Pounds*
1920	1,512.25	76,296	360,067.4	238.10
1921	1,512.25	59,076	359,029.0	237.41
1922	1,749.47	68,310	475,794.0	271.96
1923	1,749.47	86,064	864,536.2	494.17
1924	2,629.14	90,017	1,030,823.2	392.08
1925	2,629.14	83,893	1,019,260.0	387.67
1926 (6 months only)	2,629.14	81,807	594,976.8	226.30
Total or average	14,410.84	545,463	4,704,486.6	321.09

The yields of all the government rubber estates in Java from trees planted in 1911 are as follows:

Year	Tappable area	Tappable area	Yield	
			Total	Per acre
	Acres	*Per cent*	*Pounds*	*Pounds*
1916	2,146.43	27.6	302,114.8	140.75
1917	4,327.44	29.3	913,140.8	211.01
1918	7,592.78	43.0	1,190,470.6	156.79
1919	8,971.04	49.4	1,777,787.0	198.17
1920	14,928.68	61.3	3,051,910.4	204.43
1921	16,287.18	69.4	3,385,672.4	207.87
1922	17,653.09	75.4	4,488,323.4	265.01
1923	20,666.49	87.2	5,732,832.6	277.40
1924	21,160.96	90.8	6,636,643.2	313.60
1925	21,879.26	90.4	7,148,033.2	326.65
1926 (7 months only)	23,051.52	93.9	5,653,817.4	252.68
Total or average	158,666.87	65.2	40,280,745.8	232.21

The reported general average yield in Java is from 605 to 660 pounds per bouw (1 bouw equals 1.754 acres) and for selected trees 1,430 pounds per bouw.

At the H. A. P. M., Sumatra, the average yields per acre from the mixed trees (young and old trees) are as follows:

Year	Yield per acre	Year	Yield per acre
	Pounds		*Pounds*
1919	288	1924	366
1920	297	1925	424
1921	276	Average	328.9
1922	326		
1923	325		

At the Goodyear Rubber Plantations, Dolok, Merangir, Sumatra, the average yields per acre in pounds from trees of different ages are as follows:

Year	Area	Average number of trees tapped daily	Yield	
			Total	Per acre
	Acres		*Pounds*	*Pounds*
1915 (4 months only)	195.7	14,800	9,850	50.3
1916	412.14	26,558	63,100	153.1
1917 (11 months only)	422.38	28,697	65,000	153.9
1918	488.3	31,465	136,589	279.7
1919	952.25	50,944	221,137	203.2
1920	1,419.83	81,378	330,638	232.8
1921	1,714.5	94,964	449,251	262.0
1922	1,807.95	97,299	477,779	264.2
1923	1,294.25	78,932	564,792	436.4
1924	3,285.2	19,381	1,139,708	349.9
1925	6,418.58	469,559	2,754,302	429.1
1926 (5 months only)	7,041.7	632,198	1,497,470	212.6
Total or average	25,452.78	1,626,175	7,709,616	302.9

The average yield per acre of this company was 302.9 pounds from mixed tapping systems while on daily and monthly alternates were 244 and 234 pounds per acre, respectively.

The productions per acre of the estates owned by different nationalities in Sumatra are as follows:

Nationality	Area		Yield	
	Planted	In production	Total	Per acre
	Acres	*Acres*	*Pounds*	*Pounds*
Dutch	150,420.53	113,968.27	35,140,872.8	308.33
British	150,968.87	124,310.16	35,031,013.6	281.89
French and Belgian	56,479.02	42,660.37	14,459,665.0	338.94
American	74,519.90	62,532.99	22,524,801.2	360.52
Swiss	5,253.69	3,149.25	1,248,515.4	396.44
Japanese	11,122.41	4,147.13	1,091,591.6	263.21
German	5,527.86	4,559.62	2,332,763.4	511.61
Norwegian	1,894.49	459.42	34,100.0	74.22
Total or average	456,186.77	355,787.21	111,863,323.0	361.88

The low production per acre of the British-owned estates was due to the voluntary restriction.

In Siam the productions per acre in the different rubber sections during 1924 and 1925 are as follows:

Section	1924			
	Area		Yield	
	Total	Mature	Total	Per acre
	Acres	*Acres*	*Pounds*	*Pounds*
Circle I	8,242.0	3,392.8	584,892	172.39
Circle II	29,805.2	23,499.6	4,028,244	171.41
Circle III	46,694.0	30,378.4	10,064,340	331.39
Total or average	84,741.2	57,270.8	14,677,476	225.03

Section	1925			
	Area		Yield	
	Total	Mature	Total	Per acre
	Acres	*Acres*	*Pounds*	*Pounds*
Circle I	10,812	4,974.8	2,880,900	579.09
Circle II	33,653.6	26,724	4,722,652	176.72
Circle III	56,067.6	33,028.4	5,525,652	167.30
Total or average	100,533.2	64,727.2	13,129,204	307.70

The average productions per acre were 225.03 pounds in 1924 and 307.7 pounds in 1925.

In Indo-China the average productions per acre from various provinces are as follows:

Year	Baria	Bianhoa			Giandinh
	Estate 1 planted 1910–12	Estate 2 planted 1910–12	Estate 3 planted 1911–12	Estate 4 planted 1910–12	Estate 5 planted 1910–12
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1916	....	....	....	102.43	....
1917	73.92	106.88	207.53	155.87	222.67
1918	369.35	178.13	255.38	274.33	286.80
1919	557.97	258.30	267.20	326.88	344.69
1920	657.32	291.09	333.12	285.02	314.98
1921	882.67	445.34	325.99	338.46	....
1922	835.46	445.34	368.25	350.04	416.84
1923	496.11	350.27	....	423.08	445.34
Average	557.11	297.33	292.91	282.01	338.55

Oil seeds.—Besides the many varied uses of rubber, the oil extracted from the seeds has been found a useful substitute for linseed oil for varnish and paint and for soap making. The kernel is said to contain about 18 per cent oil. There is no difficulty found in extracting the oil of the Para rubber seeds, but there is difficulty in the collection of good sound and fresh seeds and it is said that unless the seed is dealt with soon after its fall from the tree, the oil content becomes rancid, which detracts from its value considerably. In Indo-China, however, this is remedied by drying the seeds to about 100° C. for about half an hour if all can not be milled immediately. In milling, the seeds are first crushed and then fed into an oil engine with expellers. An oil mill used for African oil palm and for copra is also employed for rubber seeds in Indo-China. The oil extracted by the expellers passes through a wire sieve and the cake stays outside the expellers. It is said a woman can collect 50 kilos of seeds for 40 piaster cents (a piaster approximately equals 96 centavos).

IMPROVEMENT OF YIELD BY SELECTION

In Sumatra, Borneo, and the Malayan Peninsula are large areas which are being planted by small land owners, and the rubber estate owners realize that unless they do something to increase their yields and thereby reduce their costs, they will eventually meet with severe competition from the small planters. It is for this reason that they have seriously taken up the question of selection and bud grafting. This is one of the ways employed to reduce the cost of production—by increasing the present yield by selection.

In Ceylon, the Rubber Research Scheme has about 123 mother trees under observation, 12 of which are said to be really good yielders. A similar study has long been under way in Sumatra and Java by the government as well as private institutions especially by the A. V. R. O. S., the Rubber Central Experiment Stations, the H. A. P. M. and the Goodyear Rubber Plantations. By selection the yield has been improved very considerably more particularly in Java and Sumatra.

All mother trees are not found to breed true to type, but on the other hand there may be in a grove excellent trees giving much higher yields than the average. It is from these high yielding trees that they get their seeds for planting and for stock plants, and scions for budding purposes. It has already been found out in rubber that not all high yielding trees produce high yielding progeny. However, selected seeds and buds produce more uniform yield than the unselected ones. Keen interest, therefore, has been taken in selecting and proving mother trees. Referring to the question of the selection of mother trees, the work is done as follows:

1. The researcher marks out with bands in black, white or red paint all the known good yielding trees in a certain plantation to make them easily distinguishable and these are watched for their daily yields. The behavior of the high yielding trees is followed very carefully, especially the rise and fall of their yields and the possible causes.
2. The latex is coagulated in cups, and the dry rubber produced is weighed separately.
3. The yield of each individual tree in the form of a biscuit is weighed after it is perfectly dried, for recording and checking up.
4. Seeds of pure lines are picked up under the trees and placed in seed cabinets where they are stored separately. Seeds of different strains of rubber trees vary in color, types, shape, marking, size, size of leaf, branching, etc., and therefore can easily be separated even picked up under the trees. But the best is to pick the ripe seeds from the tree, if this can be done.

5. Budding and seed selection should go hand in hand. A nursery for budding is then established and plants raised from selected seeds are isolated to preclude all possible crosses from other strains or poor-yielding trees or bagging is done to insure self-pollination.

Trees produced from a tree where no cross-pollination occurred: Twenty-eight seeds were planted in November 1916, 6 by 6 meters apart. The average yield was 684.3 grams in 1925. The highest yield of the seedling was 2,267.3 grams and the lowest was 193.6 grams.

6. Crossing is undertaken to increase the yield further. This is combined with using disease-resistant trees. Pollen of *H. spruceana, H. collina, H. guayensis,* and *H. confusa* are used in hybridizing the *H. brasiliensis.* Artificial pollination has resulted in the production of a few more specific crosses, but the percentage of success has been very low and quantity of production of seed is not possible. At H. A. P. M. only 2.13 per cent success has been obtained and at A. V. R. O. S., 10.90 per cent.

As a result of seed selection and budding the rubber tree, which work was started by Dr. P. J. S. Cramer in 1917–1918, now they have in Java and Sumatra trees yielding as follows:

1. Four-year old selected seeds yielding from 323 to 396 pounds of dry rubber per acre against 178 pounds from ordinary seeds.

2. Budded plants 4 years old yielded 278 pounds of dry rubber per acre; 5 years old, 300 pounds; and 8 years old, 600 pounds as compared with 178 pounds from ordinary mixed seeds. Half an acre of budded trees produced an average of 60 grams per tree per tapping which is equivalent to 1,820 pounds per acre. 95 per cent of the budded plants gave highest yield.

The average production of 9 trees of clone No. 88 in Java during 1925 was 2,456 grams dry rubber per tree when they were 7 years old. The highest yield per tree was 2,886 grams and the lowest was 1,971 grams.

3. A tree 44 years old in Buitenzorg, Java, produced 250 grams of dry rubber per tapping alternate days and tree No. 24, 10 years old gave 300 grams per tapping or an annual yield of 100.1 and 120.12 pounds of dry rubber per tree, respectively. There is also a tree in Java said to be producing about 100 pounds a year. Tree No. 78 produced 1,430 grams dry rubber in 1926 as against 1,379 grams in the previous year.

4. Of the 16 trees of clone No. 3 the average yield in 1925 was 1,850 grams. The highest was 2,830 grams and the lowest yield was 1,139 grams. And of 2 trees of clone No. 9 the yields were 1,620 and 2,303 grams dry rubber, while clone No. 16 produced 3,291 grams.

In Ceylon tree No. 12 at the Henaratgoda Garden, planted in 1877 is said to have yielded about 392.43 pounds in four years and nine months. This tree has now a circumference of about 3.12 m. measuring 3 feet from the ground and is about 25 meters high. Cuttings of this tree are now selling for about ₱1.47 per yard.

At the Goodyear Rubber Plantations the latex and dry rubber yields from high-yielding trees in cubic centimeters and grams are as follows:

Number of trees	180		214		280		441	
	Cubic centimeters	Grams	Cubic centimeters	Grams	Cubic centimeters	Grams	Cubic centimeters	Grams
Average per day tapping	278	83	263	77	276	71	202	62
Average per day for 2½ years	217	65	119	35	69	22	164	50
Percentage of time sick	21%		46%		71%		18%	

In Malaya at the Pataling Estate, of the 8-year old rubber, 21 out of the 600 trees gave 10 pounds or more dry rubber for 160 tapping days a year. The two best trees gave 20 pounds with 18 inches length of cut, 51 inches girth, 20 inches from the ground from November 1924, to October 1925.

At the H. A. P. M., Sumatra, a yield record of their selected trees is tabulated below:

Month	Yield from 1917 to 1925 at H. A. P. M. (dry rubber per acre in pounds)								
	1917	1918	1919	1920	1921	1922	1923	1924	1925
January	....	344	383	432	251	621	412	679	590
February	....	359	394	520	247	496	394	633	680
March	179	186	394	468	243	472	366	608	665
April	243	196	334	367	246	559	360	550	542
May	338	304	340	498	355	604	435	337	550
June	401	352	450	507	442	676	467	476	576
July	403	372	485	679	592	640	531	546	711
August	340	440	470	516	548	616	611	650	731
September	362	361	318	494	558	293	567	521	743
October	454	370	372	550	511	337	498	608	661
November	392	321	306	443	553	333	553	553	658
December	366	442	367	553	654	390	608	588	557
Total	[a] 3,478	4,047	4,713	6,027	5,200	6,037	5,802	6,749	7,664
Yield per acre	278	323	369	482	416	483	464	540	613

[a] Ten months.

At the H. A. P. M. it is said that good-yielding trees produce as much as 25 pounds a year.

At Tjipetir, Java, a tree planted about 1907 or 1908 has recorded a yield from 250 to 300 cubic centimeters of latex per tapping day.

Various correlations have been worked out in Java, Sumatra, and Ceylon and gave the following results:

1. No relation between the yield and the size of the leaves.
2. The bark thickness is probably inherited from the mother to a certain degree.

3. There is a considerable variation of the number of latex rings in the seedlings from one mother tree, and this character is not strongly inherited from the female parent.

4. Selection by the use of seeds, of which both male and female parents are high producers, is to be greatly preferred in spite of the greater difficulty and increased costs.

5. The highest number of laticiferous vessels found in Malaya was 27 and in Java the highest yielding tree has 80.

6. A study of the great variation in seed and the marking failed to yield any character which could be associated with yield of the parent tree.

7. There is no correlation between the tendency to produce more or less than three seeds in a capsule and the yields.

8. The number of latex vessels, girth and bark thickness tend to be higher in good yielders than in medium or poor yielders and in medium yielders than in poor yielders.

9. In general the girth, bark thickness, and number of latex vessels decreases proportionally with the increase in height until at the height of 20 feet they have approximately 50 per cent of the values at one foot. There is generally a rather abrupt falling off first above each branch.

10. Trees with the largest girth are not always the highest yielding trees. No relationship between yield and the increase of the girth exists.

11. Girth and cortex thickness are intimately related.

COST OF PRODUCTION

The cost of planting is variable because of the price of land, the density of jungle to be cleared off, the investment in building and equipments, variation in wages, efficiency of different races, proximity to transportation or market, method of clearing and planting, supervision, different location, yield, soil and climatic conditions, health condition, age of plantation, overhead, depreciation, amortization of the life of plantation, etc. The cost of operation in detail from planting to manufacturing raw rubber has been worked out on some of the plantations in Sumatra, Java, and Malaya, but these are not included in this report since they are very voluminous. A short summarized statement of the all-in cost of the production of dry rubber is herewith given only from the different countries.

In Java during the year 1925, the cost of production of the government-owned plantations was ₱0.1736 per pound of dry rubber. To this cost should be added ₱0.0556 per pound for interest on the capital invested, ₱0.0651 amortization, ₱0.0133 for administration. The total cost was, therefore, ₱0.3076 per pound as against ₱0.52 in 1924. For the first seven months of the year 1926, the average cost was ₱0.1934. High cost is due to young rubber areas. The cost of production f.o.b. per pound of dry rubber per year of the government rubber estates in Java is as follows:

Year	Semarang (¢)	Tjipetir (¢)	13 Estates (¢)
1914			83.82
1915			69.09
1916		78.68	68.91
1917		51.36	62.14
1918		43.18	54.32
1919		53.64	75.77
1920	52.32	46.23	80.46
1921	36.73	29.41	63.00
1922	26.91	21.73	48.68
1923	21.68	20.32	38.68
1924	19.14	21.23	37.91
1925	20.13		38.41
1926	(a) 18.05		(b) 43.14

[a] Six months. [b] Seven months.

In Ceylon the cost of production of the full bearing trees is about 29 centavos per pound of dry rubber including tax. The capital cost of opening land is about ₱367.65 to ₱514.70 per acre which may be distributed in 6 years, with greater cost in the 5th and 6th years for buildings. This includes machinery, buildings, and other work and cost of the land, which is calculated to be ₱110.29 per acre. Estates 1 and 2 produce at a cost of 18 to 19 centavos.

In Burma the all-in-cost per pound of dry rubber in Indian Rupees cents is as follows:

Year	Estate I	Estate II	Estate III
1923		0.51	
1924	0.543	0.50	0.58
1925	0.540	0.42	0.40

(NOTE.—IR. 1=₱0.9732)

In Sumatra one of the largest companies produced at 50.70 centavos per pound of dry rubber in 1922 including land rent, depreciation, and administration. Without these charges the cost of production was only 34.51 centavos as against 38.64 in 1921. On some of the old estates the cost of production runs only from 16 to 32 centavos a pound.

In Malaya a block of 250 acres is regarded as the smallest unit which can support an owner-manager. On Estate 1 the cost of production in 1925 is 29.53 centavos per pound of dry rubber but from this should be deducted ₱0.024 represented by the expenditure on immature rubber so that the net cost is really only ₱0.27. The all-in-cost of five other estates in 1925 is as follows: Estate 2, ₱0.26 as against ₱0.32 of the previous year;

Estate 3, ₱0.32; Estate 4, ₱0.33; Estate 5, ₱0.33 as against ₱0.42 of the previous year; and Estate 6, ₱0.32 as against ₱0.37 of the previous year. In Malaya, however, there is tendency for extra rates, and it is only to be expected that labor should share to some extent in the increased prosperity of the rubber industry.

NATIVE PLANTING

The foregoing report has reference only to the plantation rubber, and it should not be amiss here to give the method involved in planting rubber on a small scale, since nowadays the native rubber is greatly affecting the market.

Development.—The development of the native planting in Sumatra and Borneo especially has been very remarkable during the last few years due to the increase of the price of rubber. The actual amount of land planted to rubber by the natives in Sumatra and Borneo is not exactly known, but it is certainly very great. For in 1925 alone the Dutch East Indies exported about 73,400 tons of native rubber as against 96,082 tons of estate product.

The cost of native planting is almost negligible and absolutely no capital is required and if there is any at all it is not recorded. In this way, a considerable number of acres have been and are now being planted. The small rubber planters in Ceylon, Malaya, Sumatra, and elsewhere are now in a very flourishing condition and mills and newly planted areas are springing up in all corners, but more particularly near the houses, roads, or river banks so as to have easy transportation. The native planters, in a small town of Palembang, Sumatra, in 1925, imported 2,500 Ford autos for their use and a year later they were replacing the Fords with more expensive makes, such as the Dodge.

The size of the native plantations varies from a few trees to about ten acres and the average is probably less than an acre.

Method of planting.—The method of planting is extremely simple. The natives cut the jungle and burn it, then plant it with food crops, such as rice, corn, root crops, etc., and at the same time rubber stumps are set out in small holes at various distances usually from few feet to 20 feet. Three feet is a very common distance. The food crops are taken care of in the usual course of events whereby the rubber is also kept clean, and after the land is abandoned for food crops, which is usually after the second year's planting, the weeds especially cogon are allowed to invade the rubber till the latter are tappable.

Small rubber nurseries are established along the bank of rivers or rubber stumps, for plantings are oftentimes taken only from the germinated seedlings under an old rubber plantation. These are bundled together and soaked in water until ready for planting.

Tapping begins when the trees are about 8 to 10 inches in girth or about 3 to 4 years old. The planter, then, during this time has to employ tappers if he is not able to tap all of his trees on a share system. The tapper or the planter himself before tapping the trees is obliged to cut down the weeds which have been allowed to develop under the rubber trees to facilitate his daily tasks. Tapping is performed in a very crude way. The bark consumption is great and tapping is done at various heights. They tap more conservatively with high prices and stop when the price is low. The hired tapper has to provide his own tapping and collecting implements. In the majority of cases empty milk cans are used for collecting cups and kerosene cans cut in half for coagulating pans or sometimes the latex is coagulated only in a hole in the ground. Spouts are made of tin, but leaves of mango and other plants are sometimes employed. In most cases no cup holders are employed and the cups are only placed in the ground.

In Sumatra the native rubber is coagulated with alum in varying amounts and commonly not even in solution. Two spoonfuls of powdered alum is sometimes put in every half can of undiluted latex. The native in this country makes the rubber in the crudest of lumps and sells it in slab form where no drying is being done. These slabs are taken to the market by floating them down the rivers and sometimes in bamboo raft or sacks and sold to the middle men, usually Chinese, who in turn tranship them to Singapore for remilling or reconditioning into blanket crêpe having four grades. The coagulum is pressed a little by other planters, in which way the well known thick slab is produced. Dirt and sometimes the scrap rubber, shavings, stones, etc., are incorporated with the slab to increase its weight especially when the price of rubber is high. Undried slabs, however, predominate.

In Malaya and Ceylon, however, native rubber is prepared by a much better system and is identical with estate rubber. Acetic acid is used in coagulating the latex and the coagulum is pressed with a bottle, wooden pin or a small hand roll. The natives of these two countries prepare either plain or ribbed unsmoked or smoked sheets dried for a few days under the sun.

Factory.—It is nothing but a small grass shed or under the house.

The trees owned by native planters are in a fairly good condition, especially the newly tapped trees, but because of the result of heavy tapping it has been found that the bark consumption of the native rubber lasts only for 12 years and no bank renewal is possible. Close planting also influences the rapid exhaustion of the trees and also excessive tapping. Trees are only rested when the price of rubber is low and at the harvesting time of rice. New plantings are, therefore, being set out every 12 years.

SUMMARY

1. All the rubber plantations in the Middle East were started from the introduction made by one Mr. H. A. Wickham in Ceylon and Malaya.
2. The first commercial plantation of rubber was started by the English in Ceylon and the Dutch in Java, both by the government. The latter Government is still running 15 rubber plantations profitably.
3. The climatic and soil conditions are generally very suitable for rubber in those countries. Typhoons are practically unknown there, but slight storms have occasionally destroyed trees both in Sumatra and Ceylon. Several dry months do not affect the rubber to a great extent.
4. Rubber has been found to grow well in all kinds of soils and at varying altitudes, but it does best on undulating land with loamy soil and below 2,000 feet. Above this elevation the growth is retarded.
5. The land premium or rent is rather cheap both in the British and Dutch colonies and land is easy to acquire especially in the Dutch East Indies.
6. Native labor is plentiful and cheap and the wages are about the same as those in the Philippines if all allowances given to laborers are taken into consideration and the overhead-charges
7. The clearing of the land by the "caiñgin" system and turning up the soil with native hoes is so far the most economical method in vogue in the planting of rubber, after suitable cover crops have been planted and the roads, drainage ditches, dikes, and catch pits constructed.

8. No benefit has been derived by planting from trees in holes blasted out by dynamite either in yield or growth of the trees.

9. Removing the stumps by human labor before planting is more favored than the use of either tractors or stump-pullers.

10. What the best planting distances are in still a disputed question, but close planting is common in opening up of a new plantation followed by selective thinning later to about 80 to 100 trees to the acre.

11. The planting of selected budded plants alternated with selected seedlings is taking the place of either purely budded plants or selected seedlings alone.

12. Marcotting and growing by cuttings has proved of no practical value for the propagation of rubber. Grafting has proved equally good as budding but it is too laborious, and therefore budding is much favored. The so-called "Forckert" system is considered at present the most desirable for budding rubber.

13. Planting is done either by the seed-at-stake method, by stump or by basket. The first named is the most common and economical method. However, planting by basket is the surest although the most expensive.

14. The prevention of soil erosion and diseases are the two most important problems under consideration there. For the former the planting of cover crops, the building of dikes, catch pits, and terracing the land have been resorted to. So far no satisfactory cover crop has been found for thickly shaded plantations. However, for young rubber *Centrosema pubescens* and *Calopogonium mucunoides* are found very satisfactory, and *Vigna oligosperma* for a moderately shaded plantation. Because of soil conservation by means of contour planting and cover cropping the yields have been increased and good bark renewal has been better.

15. Manuring and cultivation by forking or plowing the rubber have both proved a failure from the standpoint of income, except on white soil in the case of the former. Ammonium sulphate and nitrate of soda are considered the best. The former is slightly better because it is less subject to loss by leaching. It is best when applied before or during wintering.

Clean weeding with hoes is favored more than any method of cultivation in vogue, but cover cropping is rapidly taking the place of clean weeding.

16. Replanting is not very successful on old plantations unless done when the trees are young.

17. Pruning has been found inadvisable except as regards dead, diseased and low hanging branches and on young trees.

18. The old methods of tapping are disappearing in favor of 1 cut on either one-half, one-third, or one-fourth spiral done alternate days or months, and by the exclusive use of the "gauge." "Jebong" and the chisel-like tapping knives.

19. Tapping is done early in the morning and not higher than 40 inches from the base except on budded plants.

20. In opening young trees they seldom go above 18 to 20 inches in height and an allowance of one inch for opening and two inches at the base is provided for.

21. Left cuts yield more than the right cuts, and the daily incision not deeper than 1 to 1.5 millimeters to the innermost bark and not more than 25 degrees angle is best.

22. The bark consumption is 1½ to 2 inches monthly for daily tapping and 1 to 1¾ for alternate day or monthly period. Five to six years bark renewal is found sufficient for the first while for the second and third it is much longer.

23. One hundred fifty to five hundred trees is the tapping task.

24. Aluminum collecting cups and coagulating tanks are now rapidly taking the place of the old glass or earthen cups and the cement tanks with glass or Chinese wares except in Ceylon where coconut shells are still widely in use.

25. Formic acid and sodium silico-fluoride as coagulants are taking the place of the acetic acid in some estates.

26. Para-nitro-phenol is now employed as a mould preventive for smoked sheet and for crêpe. It is believed that this with sodium silico-fluoride as a coagulant will eliminate the costly operation of curing and smoking the rubber sheets.

27. The manufacture of crêpe rubber has been improved by partial coagulation of the latex.

28. Ammonia, sodium, and potassium hydroxides are used for latex preservatives.

29. Raw rubber is prepared either in the form of smoked sheet (ribbed or plain sheet), crêpe (thin or thick), sole-crêpe, slab and sprayed rubber. And the lower grades are made into compo or blanket crêpe. The manufacture of rubber on a large scale by spraying will in time undoubtedly take the place of the present laborious and expensive process of coagulation and machining in the future.

30. The method of shipment of latex abroad has been improved by condensing the latex before shipment, thus eliminating the costly freight.

31. The drying of the smoked sheet, the crêpe, the slab and the compo or blanket crêpe is performed in a similar way in the countries visited. They differ only in the construction of the drying and smoke house.

32. When a sheet is perfectly dried or smoked can be judged only from its appearance. It should contain only about 0.5 per cent moisture and crêpe from 0.40 to 0.65 per cent.

33. Rubber is packed in cases or baled in mats or sacks after being sorted and pressed. Packing in sacks and baling in mats are much cheaper than packing in cases

34. In Ceylon and Malaya part of the rubber is marketed by public auction and a small quantity is sold locally. Most of the rubber is sent direct to London where it is sold to the consuming countries, especially the United States.

35. The rubber boom was mainly caused by the restriction scheme and because of this many of the companies were able to declare a very high dividend to the stockholders. But even when the price of rubber was low many of the estates were able to pay a reasonable dividend.

36. The yields are very variable in the countries visited. They range from 206 to 557 pounds of dry rubber per acre. The present average production per acre is higher in Malaya because of the greater age of the plantations there.

37. Selection and budding have increased the yield considerably. Seeds for planting are picked up every two or three days from and under the trees. Heavy and firm seeds obtained from high yielding and mature trees are planted.

38. The cost of production varies in different countries but the older the plantation the less the cost.

39. Rubber planting has been found equally profitable in large as well as in small holdings.

40. Accurate estimates of the potential capacity for rubber of each country visited are impossible because of the lack of statistical data regarding the land available for rubber. It may be said, however, that there is still plenty of rubber land awaiting cultivation especially in Sumatra, Malaya, Burma; Siam, and Indo-China.

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(*a*) Forty-nine-year-old rubber trees at the Henaratgoda Botanical Garden, Ceylon

(*b*) A portion of the laborers' quarter at the Good-year Rubber Plantations, Sumatra

(*a*) Land ready for planting at Harvard Estate, Kedah, F. M. S.

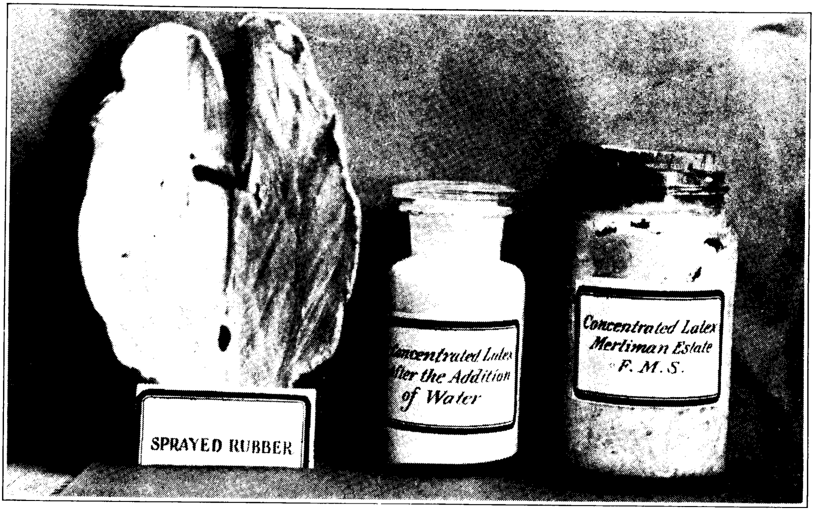
(*b*) In the foreground are baskets ready to receive sprouted seeds

PLATE III

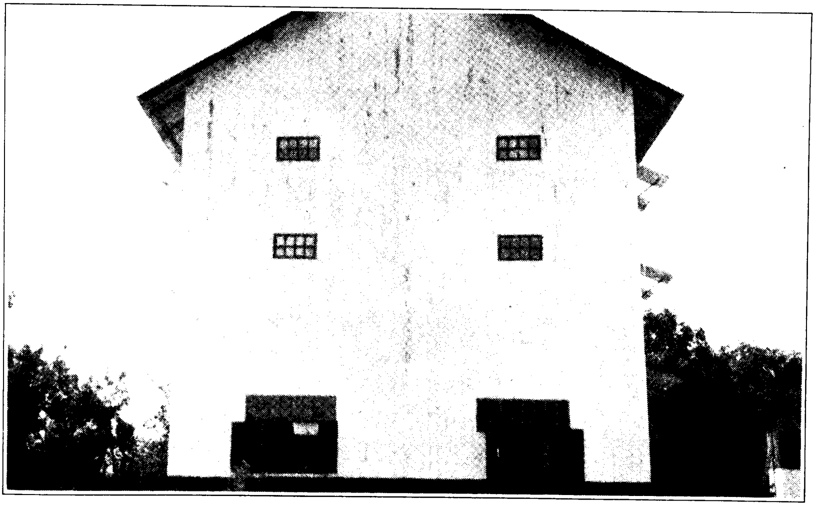
(*a*) Budded plant at the Goodyear Rubber plantations, Sumatra

(*b*) A type of smoke-house in Sumatra

PLATE IV



(*a*) Sprayed rubber and concentrated latex



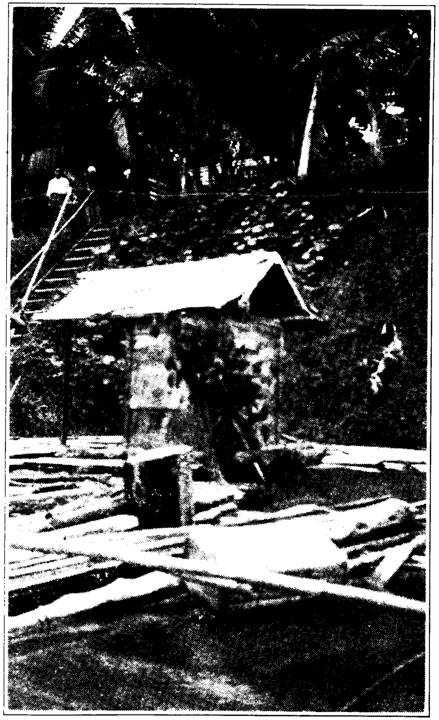
(*b*) A type of drying-house for crepe rubber in Sumatra

PLATE V

(*a*) A type of a factory-house in Sumatra

(*b*) Sorting rubber in Java

(*a*) A forty-four year old tree in Java

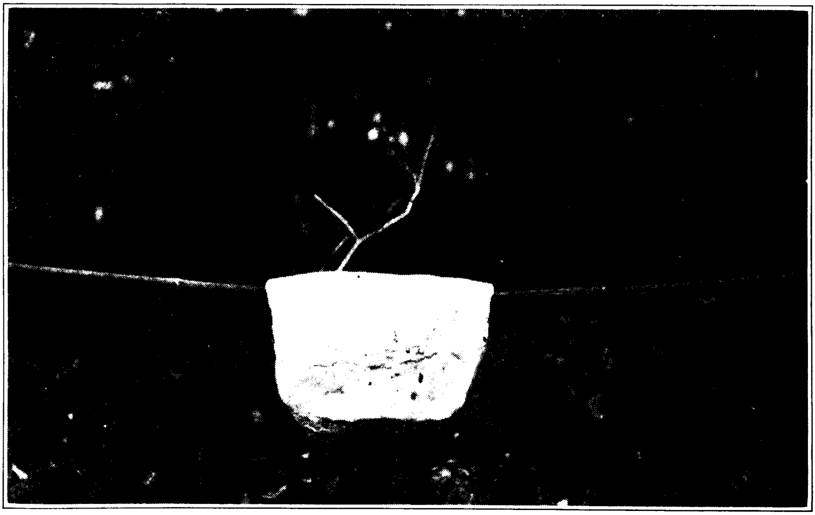


(*b*) Seedlings soaked in water, Sumatra

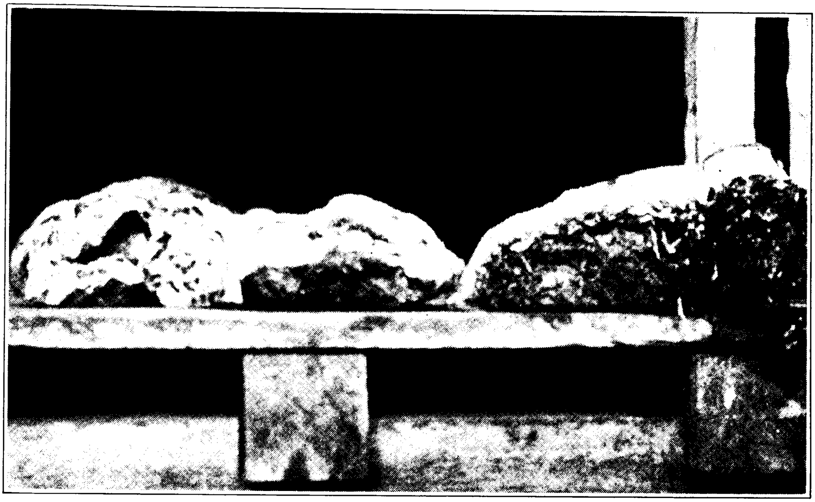
(*a*) Highly tapped trees in Djambí, Sumatra

(*b*) Kerosene cans for coagulating latex in Palembang, Sumatra

(*a*) Native rubber floating in water, Djambí, Sumatra



(*b*) Slab rubber prepared by natives in Palembang, Sumatra



(*a*) Slabs with stones and shavings inside. Sumatra

(*b*) Rolling the slabs (native factory)

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